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FLIGHT

AIRCRAFT, SPACECRAFT, MISSILES

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Hindsight . . .

ANYONE who cares to look at the full radio-approach chart for New York—or, better still, anyone with practical experience of the area in bad weather—can easily appreciate the complexity of the navigation-aid layout and the tremendous work-load it imposes on a crew following a flight clearance to one of the main airfields. New York traffic control is based on a large number of medium-frequency non-directional beacons and four-course ranges, and on very-high-frequency directional (VOR) and marker beacons. The numerous reporting points which act as stepping-stones from the airways and routes to the final approach are defined not only by beacons, but by the intersection of given bearings from pairs of beacons—and not always two VHF or two MF beacons. To follow the stepping-stones means continuous tuning of four navigation radios in the cockpit to obtain bearings from which position or required heading must be derived. The let-down and approach sequence is defined in a clearance some time beforehand, but there is little guarantee that it will not subsequently be changed several times.

For the jet airliner captain there is the additional complication of letting-down from a considerable height in a fast and relatively unwieldy aircraft as well as in following the stepping-stone sequence. The controllers on the ground can be no less busy or harassed in marshalling the relentless flow of traffic. Radar advisory service without height indication does little more in so crowded an area than tell the pilots about everything which, in plan position, is close to them, whether it be 10,000ft or 10ft distant vertically. Certainly, both the pilot's capacity and the communications frequencies are more than fully occupied.

All this has been reported and commented upon many times, verbally and in writing. But now a tragic collision has thrown the situation into focus—or out of it, according to one's point of view.

. . . and Foresight

Every captain who has approached or left New York during past years has more or less successfully followed the procedure. Must we now conclude that the whole system is inadequate or dangerous? Should the arrangement of beacons be modified or the beacons themselves improved (for instance, by the addition of DMET)? Is an improvement to be sought in the traffic control system on the ground? Or should an entirely different aid be adopted?

Since 1957 professional organizations and individuals—including the Federal Aviation Agency—have supported the last of these remedies. But now all that is water under the ICAO bridges. Internationally, the airlines have been committed to a marginal improvement (Vortac) on the New York-type system; and when traffic densities build up to New York level in other parts of the world, the same dangers and the same tragedies must become more likely.

The Decca Navigator Co, on whose equipment many of the alternative proposals seem to have been based, have inevitably reacted to the New York disaster. They claim that they not only foresaw it, but manufacture equipment which could have prevented it. An effective area-coverage aid with pictorial presentation makes it possible to fly a designated track accurately after one tuning of the receiver. The pilots' work-load is drastically reduced, the accuracy of flying greatly improved. For many reasons, good and bad, the actual Decca equipment was rejected by the United States and consequently by the world in general.

But the day of pictorial presentation with easily followed printed tracks has unquestionably been brought nearer. The picture may be based on Decca, Doppler with fixing aids, or on combinations of aids. One factor seems certain. Pictorial presentation, and all that it implies, must be generally adopted.

FROM ALL QUARTERS

NATO Air Defence

UNDER a unified air defence system for Europe, in which the United Kingdom forms one of four NATO regions, RAF Fighter Command is to come under the orders of the Supreme Allied Commander Europe. The system devised by the North Atlantic Council provides safeguards to protect the national interests of countries taking part, their authorities retaining the right to decide the "size, composition, role and deployment" of air defence forces assigned to SACEUR.

Tragic Month

BY a grim coincidence, the two air accidents which occurred on successive days just before Christmas both happened over built-up city areas: the DC-8 involved in collision with a Super Constellation fell in Brooklyn, New York (see Air Commerce, page 1028); and a USAF Convair C-131 which had taken off from Riem Airport on December 17 came down in a crowded thoroughfare near the centre of Munich after striking the spire of St Paul's church. Wreckage struck a tram, setting fire to it, and in addition to the 20 people killed on board the aircraft (seven crew and 13 passengers) there were more than 50 casualties—many fatal—on the ground.

The Convair, carrying American students on their way to join their Service families in Britain for Christmas, was bound for Northolt. Some four minutes after take-off the captain, Maj John Connery, reported that he was having engine trouble. It is believed he may have been trying to make an emergency landing in the open area of Theresien park. Conditions were foggy. One of the passengers was Maj Connery's 18-year-old son.

This pre-Christmas period was a melancholy one indeed, for scarcely had New Yorkers recovered from the shock of the Brooklyn air crash before they were faced with tragedy in the Brooklyn Navy Yard, only two-and-a-half miles distant. Here, on December 19, the 60,000-ton *Forrestal*-class aircraft carrier *Constellation*, due to be commissioned in March, caught fire. At least 42 of the 4,000-odd construction workers on board lost their lives, and over 200 were injured; and 90 aircraft were destroyed. The cause was a leakage of jet fuel; the ship's fire-fighting system had not been connected.

Another 30 lives were lost during the same period when a Lancastrian of the Argentine Air Force crashed in San Andres de Giles, near Buenos Aires. The Air Force operates a number of Lancasters, and this was presumably one that had been converted into the Lancastrian transport version.

NATO Strategic Missiles?

THE meeting in Paris of the Council of the North Atlantic Treaty nations shortly before Christmas was marked by the first public airing of a fundamental defence controversy. Even allowing for such weapons as Jupiter, Mace and manned bombers, the military equipment of NATO has in the past been of a tactical nature. For many months Gen Norstad, Supreme Allied Commander, has been trying to sell the idea of providing NATO forces with strategic weapons able to strike at the heart of the Soviet Union.

Irrespective of any decision taken by the 14 nations, the US Navy has announced that it plans to deploy five fleet ballistic-missile submarines to the 6th Fleet by the end of 1963, at one stroke putting 80 Polaris missiles into European waters. And the Secretary of State, Mr Christian Herter, says that the US Government "would expect other governments" to contribute towards furnishing a further 100 strategic missiles to meet the Supreme Allied Commander's needs. The American proposals are vague, but they appear to mean that some, or all, of the 14 nations will be expected to purchase these 100 from the US and make provisions for deploying them. The type of weapon is not specified, and the method of deployment is merely described as "probably under water." Should the NATO member-nations agree to the outlay of the "at least £200m" estimated unofficially, the US Government would be prepared to turn over five FBM submarines (possibly the five from the 6th Fleet) to multilateral control.

French Five-year Weapons Programme

THE French military programme law has now been passed. During the next five years 11,790m new francs will be spent: 4,928m for missiles and nuclear warheads; 4,137m for aircraft, helicopters and the Mirage IV; 947m for combat ships and a naval ballistic missile with a nuclear-submarine launcher; and 1,778.5m for vehicles and army equipment. The first element of a national deterrent force will be the Mirage IV, in service before 1964. It will have an operational range of 2,480 miles refuelled by Vautour tankers, and "unique radio countermeasures." Mirage III fighters will provide secondary cover and confuse enemy defences. The manned force will be succeeded by the French ballistic missile, for the development of which SEREB has 100m NF this year.

Conventional aircraft in the programme, besides 50 Mirage IVs and 270 Mirage IIIs, are 50 Etendard IVs, 27 Breguet Alizés, 80 light transports (probably Super Broussard, Bréguet 945 or Dassault Super Communautés), 70 Magisters and 220 helicopters, including Sud Frelons.

Belfasts for the RAF

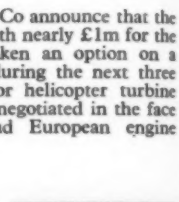
BELFAST is the name being given to the Short SC.5/10 strategic freighters which Short Brothers & Harland Ltd are building for RAF Transport Command. This was stated by the Minister of Aviation, Mr Peter Thorneycroft, when he announced in the House of Commons on December 21 that a contract had been placed with the company for ten of these aircraft. Shorts have said that they also intend to use the name for the civil version of the aircraft; the name Britannic has been dropped.

The company have stated that they propose to offer a tactical version of the military Belfast, to be known as the SC.5/20. This, they say, will be "structurally similar to the SC.5/10, but fitted with an advanced military version of the Tyne turboprop developing no less than 9,500 h.p. for take-off."

Gnomes for Italy

AS we go to press the de Havilland Engine Co announce that the Italian Agusta Co have bought Gnomes worth nearly £1m for the Agusta-Bell 240B helicopter, and have taken an option on a very much greater quantity for delivery during the next three years. This is the largest export order for helicopter turbine engines ever placed in this country; it was negotiated in the face of "stiff competition from American and European engine manufacturers."

Capt K. J. G. Bartlett



IT is with regret we record that Capt K. J. G. Bartlett, CBE, AFRAeS, MInstT, MSAE, a director of the Bristol Aeroplane Co Ltd for 17 years until his retirement last June and a former president (1954-55) of the FAI, died in Paris on December 15 at the age of 68. After his retirement from Bristol, he continued to represent the company's interests as a director of its associated concern in France, Société d'Exploitation et de Constructions Aéronautiques, and as vice-president of its Spanish associate, Talleres Aeronauticos de Barajas SA.

Capt Bartlett was born and educated in Belgium, served in the Army during the First World War and after it joined Gnôme et Rhône as manager of the motor cycle section. From 1923 to 1927 he was a director of the Belgian firm Marelli Magnetos, then joined Bristol in 1928, becoming European representative and travelling widely on the company's business.

From 1939 to 1940, Capt Bartlett served in the RAF, his work as liaison officer between the British and French air forces leading to his being made a Chevalier of the Legion d'Honneur. After the fall of France he was released to rejoin Bristol, becoming manager of the engine repair section. He was made a director in 1943, two years later becoming sales director.

When he retired from the sales directorship in 1953, Cap Bartlett was based chiefly in Paris, his ties with the Continen having been strengthened in 1950 when he was made vice-president and treasurer of the Fédération Aéronautique Internationale. He was loaned by Bristol to the MoS in 1951 to act as deputy chairman of the European Purchasing Commission, his work in this post leading to his being made a CBE in 1953.

A Dual Secondary Radar Standard

A HIGH-LEVEL MoA mission last week obtained American assurance that the new FAA secondary radar with three-pulse side-lobe suppression system would be compatible with the ICAO standard two-pulse system. Thus a USAF-inspired break with an internationally agreed standard has been averted.

Civil secondary radar is essentially the same as military IFF (identification friend or foe) and provides a ready means of identifying surveillance-radar traces. More than five years ago a civil requirement for secondary radar was formulated. Side-lobe suppression was developed, largely by Cossor in Britain, to avoid misleading triggering of airborne transponder beacons by the side-lobes of the secondary radar transmission from the ground. The military IFF Mk 10, standard in the USAF, RAF and NATO air forces, has no side-lobe suppression; such a facility was only recently required. Suppression is achieved by a two-pulse or three-pulse coding; and an Anglo-American agreement in 1957 settled on a two-pulse system. This was written into ARINC character-

***HAND-SHEIKH:** The first of Middle East Airlines' Comet 4Cs is symbolically handed over to the airline's chairman and managing director, Sheikh Najib Alamuddin, by the managing director of de Havilland Aircraft, Mr H. G. Sturgeon (see story on page 1027)*

istic 532B, agreed between Britain and America and standardized internationally by ICAO. The civil transponder had already been altered in frequency, code and mode to be compatible with IFF Mk 10. Development then went ahead in the US and Britain. Transponders are now carried in many jet airliners and are mandatory over certain parts of the United States eastern seaboard and on the high-level jet routes from New York to San Francisco. The first secondary radar in Europe, made by Cossor, was delivered last month to London Airport for operational evaluation.

Recently the USAF decided that side-lobe suppression was necessary for the military equipment; but, because IFF Mk 10 could more easily be converted to a three-pulse than to a two-pulse side-lobe suppression, the three-pulse system was adopted and, in accordance with the civil/military common-system concept, the FAA decided to follow the USAF lead. MoA in Britain immediately reacted and the high-level mission travelled to Washington to try at least to ensure that the new three-pulse system would remain compatible with the ICAO two-pulse. Technically, there is little to choose between the two systems.

The Handley Page Outlook

SPEAKING at his company's senior staff dinner, held in London last week, Sir Frederick Handley Page referred to the recent newspaper story of an American take-over bid for the business. Again refuting it, he said that it apparently arose out of the company's efforts to sell the Herald in American markets. As a simple law of logic, "we would not sell the company, but the Herald—and we might sell something of theirs in exchange."

Sir Frederick also spoke of current H.P. progress with laminar flow and (though he did not enlarge on the point) "some other very interesting projects we have in hand."

Lord Douglas of Kirtleside, chairman of BEA, proposing "The Company," recalled his own early days as chief pilot of Handley Page Transport Ltd in 1919, then came up to the present, saying that "the whole industry" was watching the laminar-flow experiments with interest. The supersonic transport, he felt, would not come for ten to fifteen years, "not so soon as some think," but he eagerly awaited the first flight, now within a month or so, of the H.P.115 [Handley Page's single-seat experimental miniature of a supersonic airliner].

During the evening three convincing colour films of the Herald's Indian, Scottish and South American tours were shown.

More US/Europe Links

FURTHER evidence of the widespread efforts of the US "aerospace" and supporting industries to increase their footholds in Europe—particularly in the Common Market countries—is provided by agreements announced by United Aircraft and Sprague Engineering. United Aircraft already have one major foot in the Common Market with Pratt & Whitney's effective dominance of SNECMA, the largest continental aero-engine company. Now, to further the interests of Hamilton Standard, United Aircraft have acquired a 15 per cent interest in Ratier-Figéac, a major French accessory firm and a Hamilton Standard licensee.

***TECHNICAL APPRAISAL** of a model of the Bristol Siddeley high-altitude test plant, where testing of ramjet engines is carried out, by some of the 22 RAF and RCAF officers from the Royal Air Force Technical College at Henlow during their recent visit to the Patchway works of Bristol Siddeley for a day's course on ramjet engines*

Sprague Engineering, of Gardena, Cal, are a major producer of hydraulic, pneumatic, fuel and air-conditioning test equipment, together with ground power units and a wide range of related support and test equipment. Having opened an office in Rome earlier this year, they now announce an agreement with Aeronautica Macchi of Milan, "for close collaboration in the manufacture and sales of the Sprague Engineering line of aircraft and missile support equipment and components in the European, Middle East and North African area." Macchi's role is not stated.

South American Markets

FOLLOWING the Prime Minister's recent appeal for a greater export effort, the Dollar Exports Council has been re-formed as the Western Hemisphere Exports Council and its scope increased to cover the balance of the Caribbean and of South America in addition to its existing markets. Announcing this change, Lord Rootes (chairman of the Dollar Exports Council since its formation in 1951, and continuing as chairman of the re-formed body) commented: "There are many valuable markets in South America and the Caribbean outside the dollar territories, and we will now be able to help and encourage British exporters to realize the potential which exists in these areas."

Aeronautics at the Universities

PRESENTING the fourth Lanchester Memorial Lecture before the Royal Aeronautical Society on December 22, Prof A. D. Young, MA, FRAeS, AFIAS, chose as his subject *British Universities and Aeronautical Research*. Prof Young is at present Professor of Aeronautical Engineering at Queen Mary College, University of London, and was formerly Professor of Aerodynamics at the College of Aeronautics, Cranfield.

Prof Young's paper began with a brief historical review of the development of university teaching and research activities in aeronautics from the early years of the century to the present, followed by a description of a typical modern university department of aeronautical engineering. Selected research topics were outlined, to illustrate the scope and tendencies of university research; and the paper concluded by considering the relationships between the universities, government research establishments and industry.

IN BRIEF

An agreement has been signed by the French and German Defence Ministers for the study and manufacture, in common, of a supersonic VTO fighter aircraft. A list of projects appeared in *Flight* for November 11.

The first annual general meeting of the rotorcraft section of the Royal Aeronautical Society is being held on Friday, January 13, 1961, at 4.30 p.m., at the Society's premises, 4 Hamilton Place, London W1.

Bristol Siddeley Engines announce that the Olympus 21 turbojet is to go into production for the RAF—obviously for a new mark of Vulcan—with the military designation Olympus 301. Its dry rating of 20,000lb exceeds that announced for any other production engine outside the Soviet Union; versions with reheat are rated at up to 33,000lb.

Lockheed Aircraft Corporation have received a West German order for 30 additional F-104G Super Starfighters. This order follows contracts previously announced for 66 F-104Gs and 30 F-104Fs.

Recent contracts ($25m in September and $19.5m in December) for military Allison T56 turboprops extend production through the first quarter of 1963, the rate of deliveries from next summer being roughly twice the present rate. The engines will be used in Lockheed C-130s and P3Vs and the Grumman W2F.

Mr K. L. C. Legg, BSc, DCAe, AFRAeS, AMIMechE, until recently professor of aeronautical engineering and head of the department of aeronautical development at the Centro Tecnico de Aeronautica in Brazil, has returned to the United Kingdom to become head of the department of aeronautical and automobile engineering at Loughborough College of Technology. While in Brazil, he was concerned in the development of the Beija-Flor ("humming bird") light helicopter.

Our associated journal *Yachting World* has a full-colour cover and re-designed title for its Boat Show Number next month (January 1961, 3s). The journal is to have a colour cover as a permanent feature.

Ten Short-haul Lessons

A SUMMARY OF MR STEPHEN WHEATCROFT'S LECTURE TO THE RAeS

DURING the past two or three years Mr Stephen Wheatcroft, BSc (Econ), AFRAeS, economic adviser to BEA, has been involved in studies of air transport operations—primarily short-haul—in Canada, India, Central Africa, the West Indies and Nigeria. In his lecture to the Royal Aeronautical Society on Thursday, December 15 ("Ten Economic Lessons from Short-haul Airline Operations"), Mr Wheatcroft summarized the most important lessons to be learned in this field.

Lesson 1: *High route-traffic density is the key to lower costs and profitable operations.*

IT was still commonly held, said Mr Wheatcroft, that short-haul airline operations were inherently less economic than long-haul. This was, he thought, a fallacy, and one which might be very dangerous for airlines and governments in the formulation of air transport policy. The belief that it was easy to make money in long-haul operations, and that the profits derived from these operations could be used to cover short-haul losses, consciously or unconsciously still coloured a good deal of air-transport thinking.

It was generally true that short-haul services were inherently more *expensive* to operate than long-haul. But when we used the word "economic" we referred (or ought to refer) to the relationship between costs and revenue. This relationship was not necessarily inherently worse for short-haul operations. There were a number of other economic factors just as important as length of haul, and these factors might often be favourable in short-haul operations, thus offsetting their inherently higher costs.

The most important of these was route-traffic density—the average volume of traffic on each route. This, without doubt, was one of the most vital factors in air transport economics.

The lecturer illustrated the progress made by BEA on the trunk domestic routes London - Glasgow and London - Edinburgh (Fig 1). As route density had increased so had the financial position improved; in the past two years the routes had been transformed from an economic liability to a profitable part of BEA's operations. The lecturer recalled the suggestion in his book *The Economics of European Air Transport* that "the most urgent European need is for a system of economic regulation directed towards lowering operating costs by creating the conditions of intensive expansion." He still held this to be valid, not only for Europe but also for short-haul operations elsewhere.

Lesson 2: *Highest practicable level of operating utilization is economically vital.*

The reason short-haul operations tended to be more expensive was because aircraft productivity tended to be lower. The short-haul airline had, of course, to pay very great attention to maintaining utilization at the highest possible level. But what was often overlooked was that this might remain true even when the aircraft had been written off the books. In its study of Indian Airlines, his committee had found that IAC's DC-3s were using about 20gal of petrol per aircraft per day in the course of daily maintenance. Because the number of reserve aircraft (17) was a high proportion of the total (42), the fuel used in maintenance was accounting for four or five gallons an hour of IAC's average DC-3 consumption, and this was a cost directly related to aircraft utilization.

What he had said about aircraft utilization was equally true of aircrew utilization.

Lesson 3: *High route-traffic density makes possible high load factors without representing inadequate public service.*

As route-traffic density increased it became possible to aim at a higher average load factor without reducing the standard of service. Mr Wheatcroft believed that the pattern illustrated in Fig 2, or something like it, had a general validity. Taking a route on which the average load factor for the month was 80 per cent, the distribution curve suggested that on 92 per cent of occasions the load factor on individual flights was higher than 50 per cent; on 64 per cent of occasions the load factor on individual flights was higher than 80 per cent; and on 10 per cent of occasions individual flights were 100 per cent full. Information of this kind was the first step in the establishment of an acceptable average load factor.

Fig 2 attempted to take into account also frequency and aircraft size. For example, a 100-seat aeroplane operating ten or more services daily on a route of high traffic density represented a turn-away risk—with an average booking group of three—when load factor on individual flights exceeded 97 per cent. The airline might think it reasonable to accept this risk on 20 or 25 per cent of occasions, when it would be justified in planning a load factor of 80 per cent. This was a far cry from the idea that 65 per cent was in some mysterious way a good target load factor in airline operation.

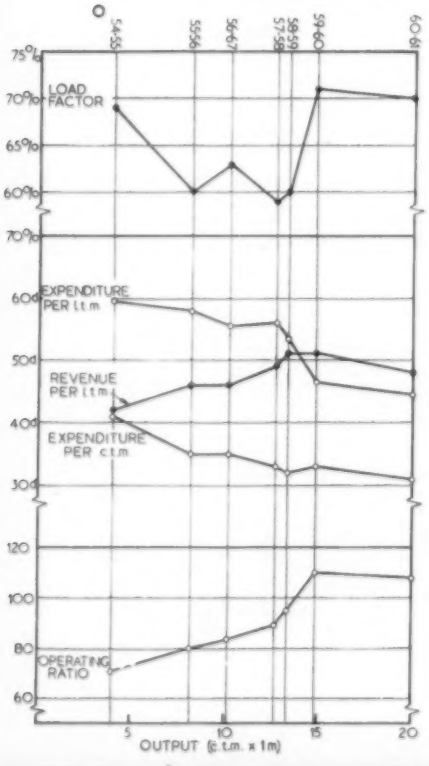
Lesson 4: *Flexibility in the disposal of payload has an important bearing on the ability of an airline to achieve high load factors.*

High overall factors could be achieved only if aeroplanes offered considerable flexibility in the disposal of their payload. Aircraft designers were inclined to take the view that this demand for flexibility was just another sign that the airline—and the commercial department was usually blamed—could not make up its mind what it wanted. The fact might be that the airline *did* know what it wanted—an aircraft which could be changed as quickly as possible for carrying its payload in different proportions. And this demand for maximum flexibility now applied to the proportion of passengers in different classes of service as well as to the proportion of passengers to dead-load traffic. A lot of new thought had got to go into seat design to achieve this objective. This flexibility was of tremendous economic importance to the airline and its value could be measured by the difference between the overall and passenger load factors.

Lesson 5: *Maximum flexibility is essential in airline pricing policy.*

The overall economic advantages derived from the complex fare structure might far outweigh the benefits of tariff simplicity. An airline might be getting somewhere near the right balance when its sales department was screaming madly that the tariff was incomprehensible. BEA's high load factor last year was to

(*Concluded on page 1029*)



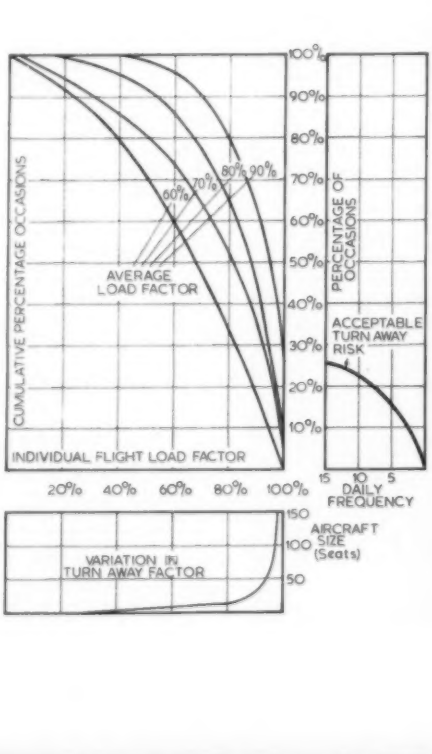


Fig 1 (left). Analysis of the economic development of BEA's London - Scotland trunk routes. Fig 2 (right). Influence of frequency of service and aircraft size on attainable load factor

Missiles and Spaceflight

Rocket Society's Washington Meeting

EARLY this month some 5,500 rocket, missile and space engineers, scientists and administrators, mostly from the United States, gathered in Washington for the 15th annual meeting of the American Rocket Society. The meeting (at the Shoreham Hotel during December 5-8) included an annual banquet, three major luncheons, presentation of more than 165 papers, and displays of unclassified equipment from 200 companies and government agencies.

The meeting served as a sounding board for announcements of several new developments in space research, including the following:—

F-1 Engine. The 1,500,000lb thrust F-1 engine being developed by Rocketdyne, a division of North American Aviation, Inc, will be ready for launching early in 1963. The engines may be clustered to develop first-stage launching thrusts of 9-12 million pounds of thrust, or more, according to Mr David E. Aldrich, programme manager for development of the liquid-fuelled engine. Appearing with Aldrich was Mr. Dominick J. Sanchini, assistant programme engineer for the F-1 project.

To launch a 400,000lb Nova-type vehicle into a low-altitude orbit, the Rocketdyne engineers proposed a first-stage booster with six F-1 engines developing a take-off thrust of nine million pounds. Such a vehicle could be used for astronomical or Earth observations, or as a space platform for the assembly of outer space vehicles. Large lunar vehicles or vehicles for manned interplanetary flight could be assembled and fuelled while in a "parking" orbit.

A first-stage cluster of six engines, together with three upper stages employing high-energy engines, could be used to place a 90,000lb vehicle into a Mars orbit, according to Aldrich and Sanchini. A capsule of such size, well-equipped with instrumentation and telemetering equipment, could send data back from either an orbit around Mars, or from a station on the surface of the planet. A similar first-stage vehicle, with three special upper stages, also could be used for the first manned Moon landing and return with a capsule weighing 20,000lb.

The Rocketdyne engineers revealed that the contract to develop the F-1 engine was not signed until January 1959, although studies on the feasibility of such a powerplant had begun at Rocketdyne in 1955 and a detailed design of a one-million pound thrust, single-chamber engine was completed in 1957.

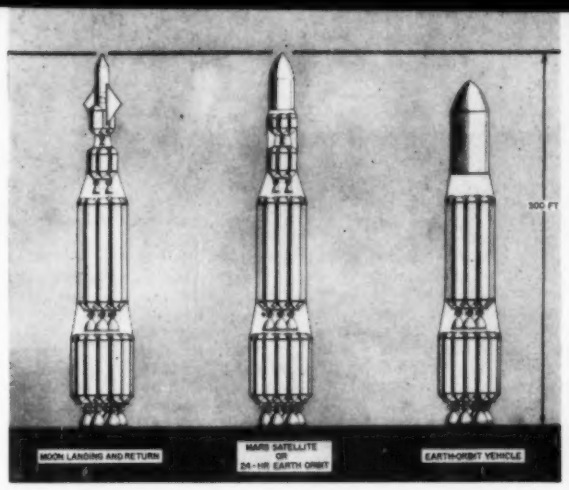
Reliability, simplicity and ruggedness were the prime design considerations in creating the F-1. Basic components of the powerplant include a tubular-wall thrust chamber, a direct-drive turbopump, a gas generator and their controls. The engine weighs about 15,000lb. The turbopump is mounted on the engine for simplicity, and all other components are on the engine or turbopump or the plumbing between them. The engine is gimballed, and high-pressure fuel is used as the hydraulic actuating mechanism.

The thrust chamber has a tubular wall for regenerative cooling, though the extension is not cooled. There is a double-inlet oxidizer dome, four integral fuel valves, and a flat-face injector. The cooled part of the chamber extends to a 10 : 1 expansion ratio, approximately 40in in diameter, 9ft 6in in nozzle exit diameter and 11ft in length. Segmented, uncooled nozzle extensions can be attached to the chamber to facilitate transportation of the engine, and to take care of any expansion ratio up to 16 : 1.

The engine consumes two tons of liquid oxygen per second and nearly a ton per second of narrow-cut kerosine (RP-1). Oxygen is fed to the dome through dual inlets to assure even distribution to the injector. Some 2,600 orifices are used to inject oxygen into the combustion chamber.

Fuel also is fed through dual inlets to a chamber feed manifold, then flows through alternate tubes the length of the chamber and returns to the fuel collector manifold. The flow then goes through four fuel valves (spaced at 90° around the chamber) into an injector feed manifold, which distributes the fuel through 32 spokes into the injector, from which it passes through about 3,700 orifices into the combustion chamber. By locating the valves downstream of the chamber a greater degree of control for timing and sequencing the fuel during engine start has been provided, as well as a repeatable minimum cut-off impulse.

The turbopump is a direct-drive unit, developing 60,000 h.p. and weighing about 2,500lb. Fuel and oxidizer pumps are driven by a velocity-compounded turbine. For balanced load distribution and to assure minimum size, the oxygen enters the pump through a single inlet and departs through two, and the fuel enters and leaves through dual inlets and outlets.



Rocketdyne F-1 engine, developing a thrust of 1.5 million pounds, may be clustered to provide launching thrusts of 9-12 million pounds in these typical Nova-type vehicles.

The gas generator to drive the turbine burns a fuel-rich liquid oxygen and kerosine mixture and consumes about two per cent of the total propellant used in the engine. The generator is about 10in in diameter and employs a double-wall combustion chamber, thus avoiding a hot outer surface that could ignite leaks.

Controls include four fuel valves that are integral to the thrust chamber assembly, two oxidizer valves on the dome of the thrust chamber, a gas generator valve, a fuel and oxidizer flow regulator for the gas generator, and a four-way solenoid valve—one of only two components in the engine requiring electrical wiring or energy. The other such component is the gas-generator spark-exciter.

Major test facilities consist of two engine stands and a thrust chamber stand at Edwards Air Force Base. A test stand for the thrust chambers and turbopump is located at Rocketdyne's propulsion field laboratory in the Santa Susana mountains, where extensive component testing for the F-1 is being carried out.

Centaur Rocket. The liquid oxygen/hydrogen engine to be used in the Centaur rocket, the LR-115, has either met or surpassed all requirements so far, according to Mr Richard C. Mulready, engineer in charge of the project at Pratt & Whitney. Firings have been made at West Palm Beach, Florida, where the company has vertical and horizontal test stands. Longest firing to date was 5½min and, as a result, the engine has been upgraded from 15,000lb thrust to 17,500lb.

Solids for Space? The cause of solid rocket engines for space launchings was argued during the meeting by Mr H. L. Thackwell, Jr, senior vice-president of Grand Central Rocket Co. He estimated that solid propellants would result in lower launching costs and estimated that by using solid propellants the cost of everything, from research to orbit, would run to $204 per pound of payload in orbit for a hundred flights. For ten flights, he put the cost per pound at $740.

These cost figures are similar to those for Saturn for the smaller number of flights, but for large numbers the solid propellants would be significantly cheaper. Thackwell estimated that a solid rocket, with a total take-off weight of over six million pounds, could be ready in about four years.

Satellite Television. Europeans soon may be able to view the latest American western television movies as they are shown in the USA, if the Hughes Aircraft Company has its way. A new satellite television system was described at the ARS meeting by Dr Harold A. Rosen, manager of the communication satellite programme of the Hughes Aircraft Company, Culver City, California.

The satellite, about the size and shape of a hatbox, would remain in space 22,400 miles above the equator, according to Dr Rosen, and could be launched by a Scout rocket. About one-third of the $15m cost of the project would go for launching vehicles and their payloads, another third for further development and contingencies, and the remainder for ground installations. Included in the latter would be a $3m layout, including an airstrip, launch pad and buildings at Jarvis Island, a small speck of land in the Pacific near the equator, about 1,300 miles south of Hawaii.

Dr Rosen exhibited the principle of his intercontinental TV system in simplified form. It consisted of a TV camera, which transmitted pictures from a TV sending station across a few feet of air to a model of the proposed satellite, which in turn retransmitted them to a ground receiving station a few feet away, which then fed the signals into a domestic television set.

In practice, the satellite would be launched into a stationary or

Missiles and Spaceflight . . .

"24-hour" orbit some 22,400 miles above the equator. Dr Rosen estimated that five boosters and payloads costing a total of $1m would be needed to give a 97-per-cent chance of getting one satellite into orbit.

The ground stations would consist of a large fixed-antenna reflector illuminated by a movable feed; a high-power UHF transmitter; a low-noise-level maser receiver; and multi-channel multiplexing equipment. Ground stations would transmit by ultra-high-frequency single-sideband at a power level of 25,000W and a base bandwidth of 4.5Mc/s. The satellite would receive a signal of two micromilliwatts. Powered by solar cells, the satellite would convert the signal to frequency modulation and retransmit it at a radiated power of 2.5W. A low-noise receiver on the ground would pick up the signal, reconvert it to UHF, strengthen it and send it out as a normal TV broadcast.

The satellite could be expected to give a year of service, according to Dr Rosen, and might give more. Both the Air Force and NASA have been approached by Hughes, which does not plan to put the satellite up without the support of government or commercial groups. The Hughes proposal is the second communications satellite suggestion made in the United States in recent months. The first was by American Telephone and Telegraph Co.

Ballistic Missile Defence. Brig-Gen Austin Betts, Director of the Advanced Research Projects Agency in the Pentagon, told a luncheon meeting during the convention that "the important thing now is to get on with the development of an active ballistic missile defence with all possible speed and with the best available talent." Because the USA was not an aggressor nation, but "inherently a strike-second force, we will have something less than the best possible opportunity to catch enemy offensive forces on the ground . . . and so an active missile defence might provide the only chance we will have to reduce losses from his first strike."

Gen Betts said that the controversial Nike-Zeus anti-ICBM system, under the overall direction of the US Army, was based on the current state of the art, and no significant invention was required for it to meet its design goals.

Less-costly Hydrazine. Aerojet-General Nucleonics announced a new process, employing fissio-chemistry, for the production of hydrazine. By placing a capsule of ammonia and uranium (U-235) in a low-power reactor, it was found that fission fragments of uranium break up the molecules of ammonia and re-form them into hydrazine, thus:—

$$2NH_3 \longrightarrow (U_{235}) \longrightarrow N_2H_4 + H_2$$

Based on its experimental results Aerojet predicts that the process, when put into full-scale operation, will result in hydrazine at about 25 cents per pound, including amortization costs.

Whose Liability? Suppose a rocket misfires and a piece of it falls on your house. Can you collect? Chances are that you cannot do so in the United States and, even if you do, prospects are that you will get very little. Mr Spencer M. Beresford, counsel for the Committee on Science and Astronautics for the House of Representatives of the US Congress, told one ARS session that recent laws passed by Congress limited government liability from military rockets to $1,000 and from civil rockets to $5,000. One could, of course, carry the suit further by showing negligence on the part of the Government if a rocket failed and hit one's home, but it is possible that the Government would refuse on the grounds of security to let you investigate.

Mr Paul G. Dembling, assistant general counsel for NASA, proposed five steps that should be taken by the nations of the world to help keep order in space:—

(1) Satellite flight plans should be filed in advance, much as aircraft flight plans are filed today.

(2) Launchings should be on a definite schedule, so as not to interfere with other launchings or space traffic.

(3) Spacecraft should be identified both by radio transmissions and painted markings.

(4) Some central bureau should record and keep records of orbits and performance. Perhaps this could be assigned to the United Nations.

(5) By pooling their resources, nations could reduce their individual costs for particularly expensive projects.

LAST WITH THE NEWS

Information concerning the first Anglo-American satellite given in *Flight* of October 21 was re-issued on December 16 in a joint press release by the Office of the Minister for Science and the Royal Society. The main message of the official announcement was that "the general layout and preliminary design [of the satellite] has been completed in a manner satisfactory to everyone concerned. Detailed subsystem design is now in progress, construction and testing of prototypes is under way and will be followed in due course by the construction and testing of flight models."

Since January of this year, four meetings of the joint working group on the satellite have been held, three in Washington and one in London. In the satellite, "four telemetry antennae will transmit in the 136-137Mc/s band to ground stations either directly from the instrument payload, or from a tape recorder which has stored data gathered during the orbit. This tape recorder will play back when commanded by suitable ground stations, one of which will be in the United Kingdom at the Radio Research Station, Slough. The experimental data will be available first to the United Kingdom scientists responsible for the instruments in the satellite."

Other "news" contained in the announcement was that informal joint discussions about the second Anglo-American satellite had taken place "in recent months," and that a final choice of experiments for this satellite would be made "shortly."

No details of the joint meeting in London were given in the announcement. At this meeting, held on September 26-30, ten British and six US scientists confirmed the overall design of the satellite as illustrated in *Flight* of October 21. In addition to representatives from the three university groups primarily concerned—University College and Imperial College, London, and Birmingham University—the United Kingdom delegates included Dr H. G. Hopkins and Dr B. G. Pressey of the Radio Research Station, Slough, and Mr E. W. Thomas, a scientific administrator on the staff of the Royal Society. The American group comprised five specialists from Goddard Space Flight Center and Mr Morton J. Stoller, Assistant Director for Satellite and Sounding Rocket Programs in the Office of Space Flight Programs at NASA Headquarters.

MERCURY SUCCESS

An unmanned Mercury spacecraft was successfully recovered on December 19 following a Redstone-boosted ballistic shot along the Atlantic Missile Range from Cape Canaveral. The capsule travelled a distance of 235 miles downrange, achieving an altitude of 135 miles and a speed of approximately 4,200 m.p.h. en route, and was picked up from the Atlantic by helicopter, taken aboard the aircraft carrier *Valley Forge* and returned to Cape Canaveral. Officials stated that winds of over 100 m.p.h. had apparently blown the capsule off course, causing it to land about 15 miles from the intended impact point.

Earlier, Mr Robert Gilruth, Project Mercury Director had described the November 21 failure of the first Redstone ballistic shot on Project Mercury. A faulty electric circuit between the ground equipment and the booster had simulated a normal booster cut-off. The cut-off signal would normally be given in flight after the booster had taken the capsule to its designed speed and altitude (approximately 34 n.m.). The normal sequence would then be for the escape-rocket tower to separate; the recovery devices such as parachutes to be armed ready for deployment; and, when the booster thrust decreased, the booster/capsule securing ring to be released. In the November 21 attempt, the escape-tower separation took place normally, the sea-level atmospheric pressure caused the drogue and main parachutes to be deployed, and the weight of the capsule on the booster prevented its separation.

The booster rose approximately one inch from the pad before its engine thrust decreased to zero. The connecting plugs between the booster and the ground services had become disconnected, and so there was no way to control the vehicle from the blockhouse after the incident. It was not possible to open the vent valves and carry out the defuelling process. It was therefore necessary to allow the liquid oxygen to evaporate, which took about 24hr.

The chief of the Mercury Redstone Project at the NASA Marshall Space Flight Center, Dr J. P. Kuettner, commented that "The surprising thing for us was that the situation has been dormant throughout the Redstone program and has never come out in almost 60 firings." Once the freak electrical connection was made, Dr Kuettner emphasized, the subsequent sequence of operation had been entirely normal.

The attempted launch from Cape Canaveral of Atlas-Able 5B, with 388lb payload intended for lunar orbit, was unsuccessful on December 15 when the booster exploded 70sec after lift-off. A description of lunar trajectories and Atlas-Able payload was published in *Flight* of December 16.

Nineteenth in the Discoverer series of satellites was successfully placed in orbit on December 20 from Vandenberg AFB, California. The satellite carried instruments for the detection of infra-red radiation from the Earth, to provide information for the development of the Midas missile-launch detection system.

A new three-stage hypersonic research vehicle was fired successfully from Woomera on December 15. The first stage, developed at RAE Farnborough, carried the vehicle to 80,000ft; the firing of the Australian-developed second and third stages then accelerated it to 7,000 m.p.h. in almost horizontal flight. Test objective was to measure the performance of second and third stages at altitude.

Seventeen papers are to be presented at a Rocket Propulsion Symposium to be held at the College of Aeronautics, Cranfield, on January 6-7, 1961. Inclusive fee for the meeting, which is organized jointly by the Royal Aeronautical Society, British Interplanetary Society and the College of Aeronautics, is £6. Further details are obtainable from the Royal Aeronautical Society.

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BALLISTIC RESEARCH ROCKETS

THIS article is based on a main lecture of the Royal Aeronautical Society, "Ballistic Research Rockets, with Especial Reference to Black Knight," which was presented by Mr D. J. Lyons, Deputy Chief Scientific Officer, Royal Aircraft Establishment, Farnborough, before the Luton Branch of the Society earlier this month.

A GOOD and well-known figure of merit in judging the efficiency of a ballistic research rocket is the payload expressed as a percentage of the all-up weight of the vehicle at take-off, for a given trajectory. Two main observations can be made from the performances plotted in the diagram (below right).

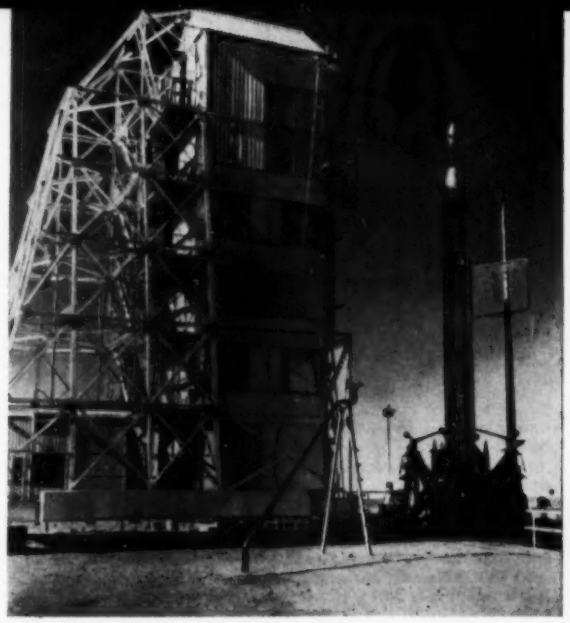
Firstly, the efficiency in terms of payload carried is immensely lowered as maximum altitude is increased.

Secondly, an appreciable improvement in performance is obtained with pump-fed liquid rockets in comparison with solid rockets, despite comparable specific-impulse figures being obtained for the basic propellant. The balance can only be redressed by adding an extra stage to the solid rockets. Liquid-fuelled rockets which are fed from pressurised tanks have few performance advantages over solid rockets as they need very strong and heavy tanks (similar to solid rocket bodies) in order to withstand the high pressure.

In making a choice between the various types of rocket for measurements of the space environment, maximum performance for a single stage is not, however, the only criterion. For maximum altitudes of the order of 100 miles or so the simple solid rockets such as Skylark have many attractions, especially as spin stabilisation or a long launcher (as is used in Skylark) can bring the dispersion down to a reasonable figure without having to put in the complexity of a control and guidance system. As maximum altitude is increased, however, and the need for a control system to reduce dispersion is introduced, the choice tends to favour the liquid rocket such as Black Knight which, besides being of higher performance, is somewhat easier to control.

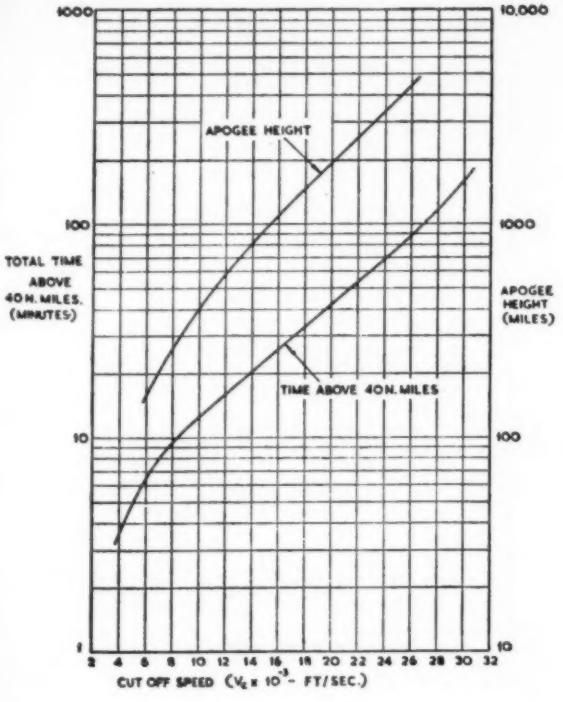
The initial design of research rocket can be critically influenced by the types of ballistic rocket for which the research is being done. If the end-products are known to be liquid-fuelled rockets, then this will predispose one's choice for the research rocket towards liquid; if the end-product were to be an air-launched solid rocket then one tends to produce a research rocket of similar character so that the main problems are encountered.

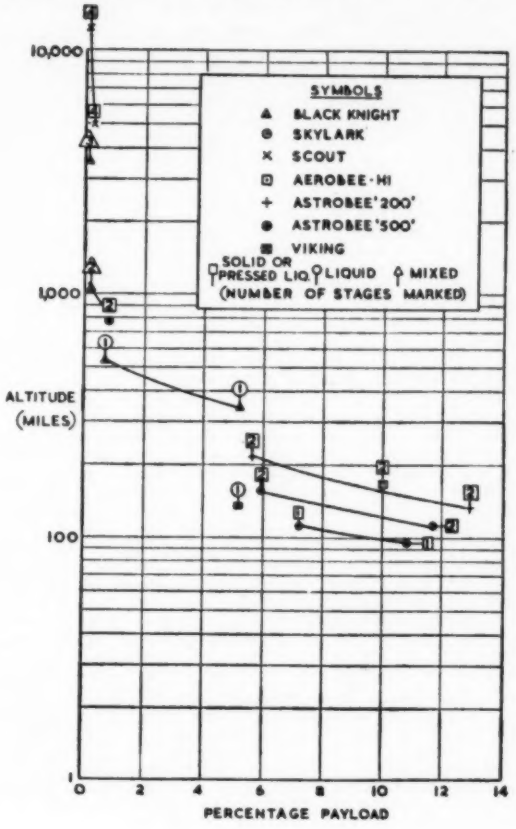
Fortunately, however, although some of the research and development problems are critically different in the different classes of ballistic rocket, many problems are identical or similar Furthermore, for a particular class of ballistic rocket, say a liquid-propelled, multi-stage missile, the main research problems



Two-stage version of Black Knight on its launcher at Woomera. Power units are the Bristol Siddeley Gamma and the Cuckoo solid-propellant motor developed by the Rocket Propulsion Establishment, Westcott

Below, total time spent above 40 n.m. altitude and apogee as a function of cutoff speed for vertically launched rockets. Right, performance of a number of vertically launched ballistic research rockets, showing maximum altitude and cut-off speed





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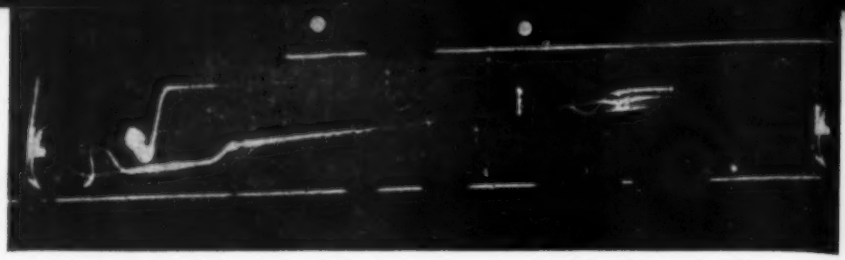


Photographic record during two-stage Black Knight re-entry, using Baker-Nunn camera (see text)

do not vary greatly with the intended use of the end-product, *e.g.* a ballistic deterrent rocket and a scientific satellite launcher present basically similar design problems.

Thus a single research rocket of a specific type can cover a wide range of common problems and can be adapted to gain information on some of the special problems of other classes of ballistic rocket. The choice of type to be used is likely to be a matter of expediency, availability or related to the immediate project development.

In the table (foot of this page) are shown the main problem areas which need flight investigation. Two of these areas which are common to solid and liquid rockets, the base heating and the collision between payloads and boost after separation, are problems that were only half-understood before flight tests began. The list is not meant to be comprehensive.

In this country the design of ballistic research rockets was not started until 1955 and the Blue Streak rocket naturally influenced the design considerations which led up to Black Knight. But a wide range of multi-stage solid designs and many variations in both the engines and the design parameters of Black Knight were considered. The main criteria used were:—

(a) it should be of very high performance both in single-stage and two-stage versions, so that the problems of obtaining high performance such as the necessity for light structure weights would be encountered, and so that exit and re-entry conditions were in the range that was likely to be encountered in future project design.

(b) the payload should be reasonably high, of the order of 150-300lb, so that complicated and comprehensive instrumentation could be used. Provision for special payloads up to 600-800lb was also required.

(c) the rocket should be controlled and guided so that the problem areas here were exposed.

(d) short development time was highly desirable as our entry into the field was late, and there was therefore a compulsion to use existing equipment arising from other projects wherever possible.

Black Knight Firings. The project started in mid-1955, and the first engine run took place in November 1956. The first static firing of a missile took place at Highdown in April 1957, and the first in Australia on a proving missile in June 1958.

The first flight firing took place in September 1958; the flight was terminated a little prematurely when 90 per cent of the propellants had been burnt, by a malfunction of the safety destruct system which correctly responded to a false cut-down signal. Since the first flight, seven more have taken place, two of which were two-stage rounds. On all but one of these flights all the propellants were burnt except for remnants of kerosine; on one occasion one chamber completely shut down, but the rocket behaved perfectly well on the other three chambers, and went on successfully to propellant exhaustion, fully under control, and guiding correctly.

The first two flights were entirely given over to proving the main stage systems and guidance; all the last six have been combined experiments covering many, if not most, of the problems already listed; all carried re-entry heads. Of the two two-stage rounds, one (the last) was completely successful. The last three Black Knights have carried upper-atmosphere experiments.

The single-stage rounds, with normal payloads, in practice reach 12,000ft/sec in a near-vertical firing (*i.e.* when the gravity losses are greatest); this was the target figure for the original design calculations. The rocket rises to a maximum height of about 600 miles in this role. With heavy payloads such as the two-stage round, the maximum speed reached in the first stage is about 9,000ft/sec, and the maximum altitude reached by both stages is approximately 350 nautical miles. During second-stage burning the speed is increased from 9,000 to 16,000ft/sec or greater, depending on the payload carried.

The fact that the Woomera range is a land range has not only provided steady instrument platforms wherever needed; it has also made possible the recovery of an enormous amount of the broken-up body pieces besides the complete re-entry heads—these latter without the parachute systems and flotation bags on which sea recovery is largely dependent. More-or-less complete combustion chambers and turbo-pump units are recovered, but with some damage due to re-entry heating. A complete Cuckoo second-stage motor case was recovered, almost undamaged due to its high drag properties, even though it re-entered at approximately 16,000ft/sec. All tape recorders have been recovered in good condition after re-entry speeds of up to 16,000ft/sec and excellent records have been obtained from the tapes. This large-scale recovery of pieces has been of considerable help in investigating minor failures, as the number of telemetry channels can never be sufficient to instrument every part and function of the round.

Among the research problem-areas is that of re-entry. The flights of the last six Black Knights, with re-entry heads, have been invaluable in assessing the value of ground test facilities—such as rocket motor sites, plasma-jets and shock tubes—and theoretical calculations, in forecasting the performance of re-entry heads, particularly in the areas of heat transfer, ablation and dynamic motion.

Each of the Black Knight re-entries has been accompanied by large radiations over the visible spectrum. The first-stage body always gives the greatest light output, due both to its size and the burning of the aluminium alloy used in its construction. The re-entry heads and the Cuckoo second stage have also given out a large light output from 50-60 miles down to very low altitudes, despite the fact that in many cases no material has been lost at all from the re-entry bodies. In these latter cases all the light output must be due basically to the ionised sheath around the body and in the wake, though the output is much larger in magnitude than forecast in original calculations.

The photograph above shows a record from the re-entry of the successful two-stage round taken from a Baker-Nunn wide-aperture, long-focal-length camera. The sideways steps on the light traces, seen also in the star traces, are the result of deliberate azimuth movements of the camera made to separate out momentarily, the traces of different bodies (such as the Cuckoo boost and the head) coming in on almost the same re-entry track but at different times. The very bright trail at the left is the track of the first-stage body starting at a lower maximum altitude due to its lower velocity.

The other partially superimposed trails on the right are the tracks of the head, the Cuckoo and a part of the second stage separated off during re-entry; the large spot at the top of these trails is the image of a flash ejected to mark the Cuckoo ignition at about 60 miles altitude. The hazy curtain-like image below the ignition point arises from a slowly decaying chemiluminescence of the atmosphere at this altitude which has been excited by the solid motor exhaust.

The research flights with Black Knight continue to give information on space environment and the problems concerned with the general advancement of the design of ballistic rockets including—as a most important group—satellite-launching rockets. Although the design of satellites themselves is outside the scope of this paper, it is relevant to note that the final proving of systems for, or examples of, the satellites themselves, will often be done on a research rocket such as Black Knight before committing them to the very expensive satellite launchers.

MAIN FLIGHT-RESEARCH AREAS

Field	Liquid propellant	Solid propellant
Propulsion	Propellant utilization.	Prevention of undue sliver remaining.
	Thrust dribble after cut-off.	Erratic sliver burning.
	Base heating from expanding gases.	As for liquid.
Structure	Kinetic heating of structure.	Kinetic heating of structure and charge.
	Bounce on launcher during static firing.	—
	Design against vibrational environment.	Design against rather more severe vibrational environment.
Control	Effect of structural flexibility on control stability.	As for liquid.
	Fuel sloshing.	—
	—	Provision of satisfactory jet deflection.
	Effect of aerodynamics on control.	As for liquid.
Separation	Light-up of 2nd and further stages.	—
	Avoidance of collision between stages and payload after separation.	As for liquid, but usually not as severe in the case of stage separation.
Guidance Re-entry Communications	Similar problems in both classes.	

FLIGHT SYSTEM SURVEY

RAE Head-up Instrumentation

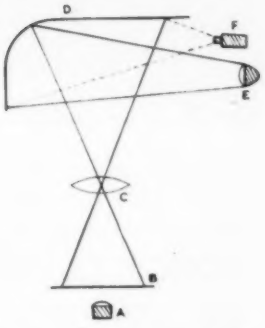
AT Farnborough recently, the RAE Instrument and Photographic Department demonstrated the new head-up flight director instrumentation and the visual flight simulator which has been developed to evaluate it. About four years ago, Mr J. M. Naish, a principal scientific officer, suggested the use of the reflector gun-sight as a means of presenting collimated blind-flying displays in the pilot's line of sight, allowing the pilot thereby to retain some outside view and also to make head-up instrument approaches. The visual flight simulator demonstrated by RAE at the SBAC display some years ago was developed with Rank Cintel and Pye to a point where it could be used in preliminary trials of the display. A basic equipment was also installed in a Meteor and 50hr flying have been completed. Some 1,200hr have been "flown" with the simulator by a large number of pilots.

The pattern of the display is illustrated in the accompanying diagrams. The ring is fixed on the aircraft line of sight and is equivalent to the aircraft silhouette in a conventional artificial horizon. The long bar is equivalent to the horizon bar in the same instrument and gives attitude indications in the normal way. The new element is the pathway of "railway sleepers" in perspective, which forms the director element. The apparent perspective of the pattern gives a strong analogy of a pathway which the pilot is following, although its movements are not representations of the earth's surface or of a desired track in the sky. As can be seen in the diagrams, the pathway lines remain parallel to the horizon bar and their aspect changes only by sideways inclinations of the centreline when a turn demand appears. The object in flying with the display is to keep the aircraft ring over the dot at the head of the pathway; and actual aircraft attitude remains apparent by virtue of the horizon bar.

In one of the displays shown at RAE a complete loop could be flown with constant instrument indications like those of the OR 946 roller blind instrumentation. When the horizon bar dropped out of sight, a vertical line appeared and was followed, in vertical upwards flight by the cross symbol used in OR 946. On the way down again the pathway appeared inverted and finally flipped upright as the aircraft left the vertical downward attitude and began to level out.

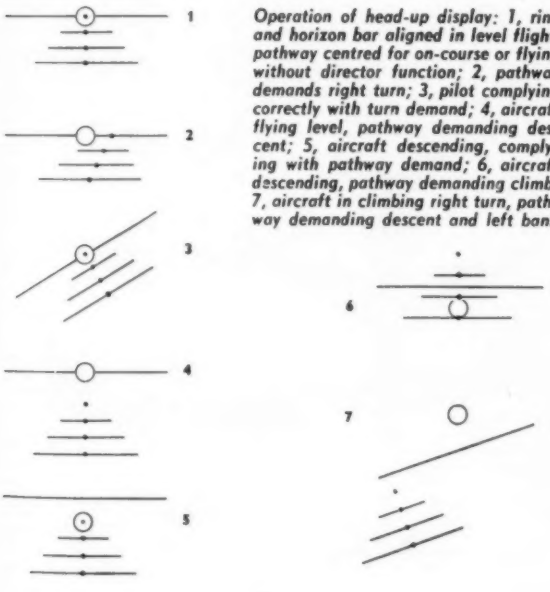
Flight's representative flew the simulator with a visual background projected on a screen and the head-up display on the reflector glass. The simulator was set up for "a fast fighter" with high rate of roll and a bank angle of 40° for a rate 1 turn, but the simulator was locked to a relatively narrow height band and there was no speed control. The symbols were presented in bright green on an inclined reflector glass about 6in wide and the head could be moved sideways over about this distance, before the fixed-ring symbol in the centre disappeared from view. The glass was about 2ft ahead of the eyes. In order to make the display usable as the sole instrument reference for an approach some speed indication would be necessary, but it seems very important that the display should not become overcrowded and obscure the external scenery. It also seems possible that a pilot would not maintain the outside scene in focus even though the display is focused almost at infinity. The eye can focus on the reflector glass, leaving the external scene largely blurred.

Simulator cockpit with OR 946 roller-blind flight instruments and head-up display. The projected external scene is on the screen



Schematic diagram of visual simulation system

A, light-source; B, transparency, moving east-west, north-south and rotating for heading; C, lens; D, curved screen; E, floodlight on sky portion of screen to give hazy horizon; F, closed-circuit TV camera scanning scene and moving in pitch, roll and height

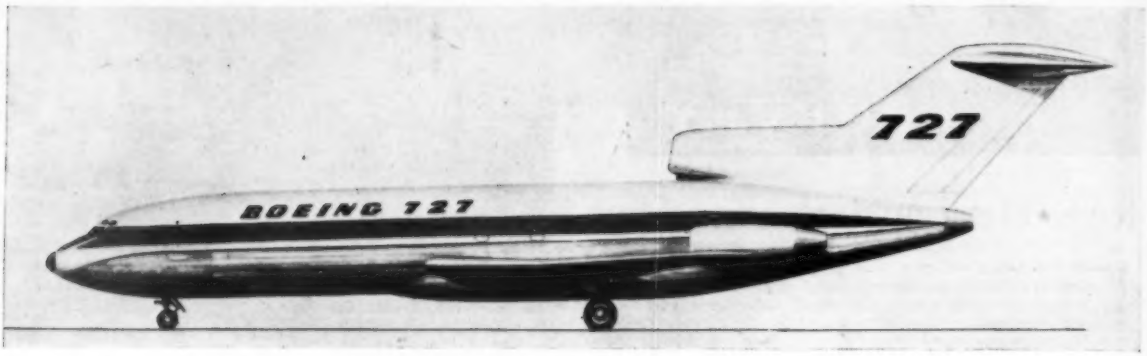


Operation of head-up display: 1, ring and horizon bar aligned in level flight, pathway centred for on-course or flying without director function; 2, pathway demands right turn; 3, pilot complying correctly with turn demand; 4, aircraft flying level, pathway demanding descent; 5, aircraft descending, complying with pathway demand; 6, aircraft descending, pathway demanding climb; 7, aircraft in climbing right turn, pathway demanding descent and left bank

So far, pilot opinion has been almost universally favourable. The display can be learnt very quickly with the minimum of instruction and pilots have generally flown about twice as accurately as with normal instruments. During the demonstration *Flight's* representative flew for one or two minutes to get used to the picture and then made a 100sec run of successive turns demanded without warning from a control console. His performance was as good as that of a laboratory technician who knew the equipment and a test pilot who had flown both the simulator and the Meteor with the first display. Errors were recorded on dials, the technician having an r.m.s. heading error average of 0.38° and *Flight's* representative 0.36°. It takes an average of four minutes for a trained pilot to learn to use the display. Another important feature is that pilots will see external objects, such as a lamp suddenly lit somewhere in the visual background, about three seconds sooner than when using conventional instruments.

The display is generated from a miniature c.r.t. with bright display and magnetic deflection and focus. The symbols are sharp and clear without afterglow trails and controlled- rather than scanning-spot techniques are employed. The pattern is generated in a transistorized unit housed in a pressurized cylinder of 10in diameter and length, information being taken from master reference gyro, compass and radio. The system was made by Rank Cintel and is more practical and much more compact than the American ANIP contact analog generator.

The visual simulator is significant in that it reproduces full visual background and aircraft motion in a relatively compact installation. A light source is positioned beneath a photographic transparency, which may be an aerial photograph, and the visual image is projected over mirrors on to a normal screen. The transparency is moved in east-west, north-south and heading senses and the projected scene is scanned by a close-circuit television camera which is moved in roll, pitch and height. The motion is therefore divided between camera and transparency and moving gantries and large models are avoided. The screen is curved on the edge away from the camera, the resulting sky background being lit by a floodlight, which produces an excellent impression of a horizon lost in mist. The moving scene is projected on to a screen ahead of the fixed-base simulator cockpit. There appears to be some loss in picture definition, but the visual impression is adequate both for research and for training purposes.



Boeing's Trimotor

BACKGROUND TO THE DEVELOPMENT OF THE 727

By ALASTAIR PUGH

THE day after the Boeing 727 was announced, a "Flight" staff member who was in New York flew to Seattle to discuss at first hand the design and engineering background behind this challenging new short-haul jet airliner. Here, to follow our analyses of December 16, is his report.

BOEING are already in business with the 727 in a big way Engineering drawings are reaching the shops, at least two partial mock-ups have been built in preparation for construction of the first aircraft, and aerodynamic and engineering testing has been in progress since June 1959. Purchasing of materials will start in March, component-purchasing following a few months later. Before the first aircraft is rolled out in the late summer of 1962 some 5,000 people will be working solely on the 727 programme. Many of those comprising this workforce have considerable previous experience of jet transport manufacture, starting eight years ago with the -80 prototype. This aircraft, basis of the -120, -220, -320, -420 and 720 series is also being used to develop the 727, notably the complex new flap. A podded JT8D on its short stalk is also shortly to be installed on the rear fuselage aft of the wing. The whole profile of the 727 has been mathematically lofted and is recorded on master magnetic tapes to which all manufacturing reference is made.

The first Boeing 727 should fly in the autumn of 1962 and nearly the whole of the following year will be devoted to flight testing. At least three aircraft will be used. These dates are here deliberately generalized; in practice Boeing have the month and day for each stage of the programme already fixed on their progress chart, although delivery of one aircraft each to Eastern and United is given as "at the end of 1963 or early in 1964."

Anyone who doubts Boeing's ability to maintain this time-scale might recall that, with the possible exception of BOAC's late-modified first 707-420s, the whole of the commercial jet family plus about 430 KC-135s have all been delivered on or ahead of programme date.

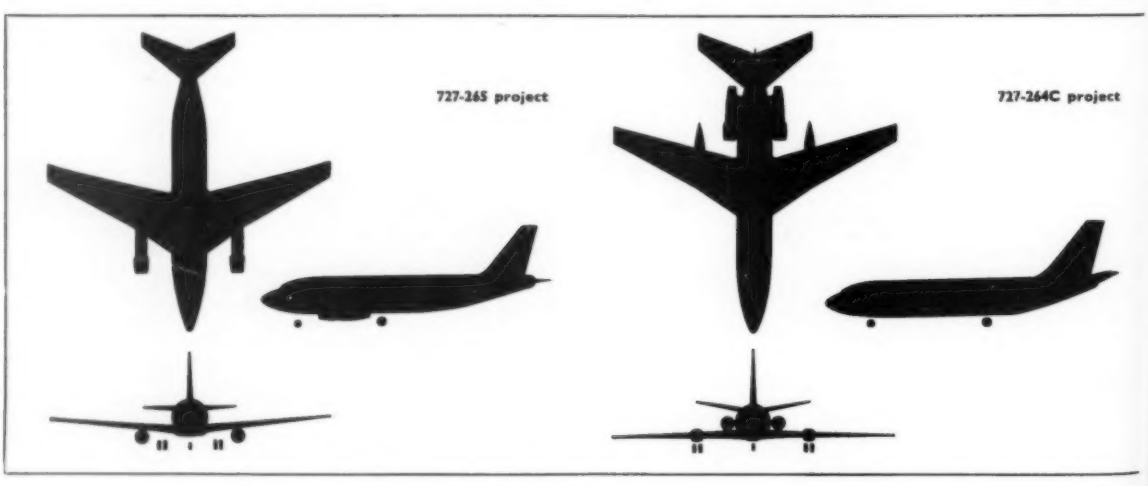
Why has there been a departure, in the 727, from the four-engined, underwing pod-mounted formula which has apparently served the remainder of the family so well? And, plagiarism aside, why does the 727 so very closely resemble the de Havilland Trident? What persuasive influence is there that so closely dictates short-range jet fashions on both sides of the Atlantic?

Firstly, in designing the 727, Boeing were never trammelled by what had gone before. Work on a short-range jet started about 4½ years ago and by August last year, not long after the work-force had been expanded to over 100 for the first time, some 65 different configurations had been studied. The emphasis at that time was admittedly on two- and four-engined layouts, in which underwing-pod mounting was preferred for the four, and aft-mounting (*à la* Caravelle) for the twin.

Before discussing the reasons for the latter, it is worth putting on record Boeing's dislike of rear mounting *per se*. They do not subscribe to the "clean wing" concept in the belief that total drag can be reduced or that the maximum coefficient of lift can be increased. Drag of the nacelle pods on the 727 is comparable with the wing pods on the 707, and although it is true that by banishing the engines to the back-end flap (and foreflap) area and lift can be increased, Boeing say that the wing pod pylons make the tailoring of the stall a much easier job; fences do not have to be over the whole top surface of a wing to do their work of controlling spanwise flow.

What Boeing will not countenance is four engines across the rear fuselage in a row. Their own experience is that, arrangement

The 727-265 twin-engined project (a previous study, the -257, had an engine on each side of the fuselage above and behind the wing) was followed by the 727-264C, a twin with engines mounted on the aft fuselage and with speed capsules for increased Mach number. Next came the two projects illustrated opposite, the four shown being among the more interesting of over 60 drafted by Boeing since the summer of 1956



for arrangement, with four engines total max lift is about the same; but with pairs of coupled engines there is what they consider to be a real danger of "contagious failure"—losing a pair as the result of a single failure. It was for this reason that the arrangement of coupled pods in the B-47 and B-36 was abandoned in the design of the 707. It was feasible in the military aircraft to protect engines from turbine-wheel explosions by making a strong intervening firewall, but nothing would prevent blade ingestion by a sound engine from a damaged one. There is also the psychological point, recorded by the USAF, that where one engine in an adjacent pair fails and the cause is not known, pilots tend to throttle back the sound one as well.

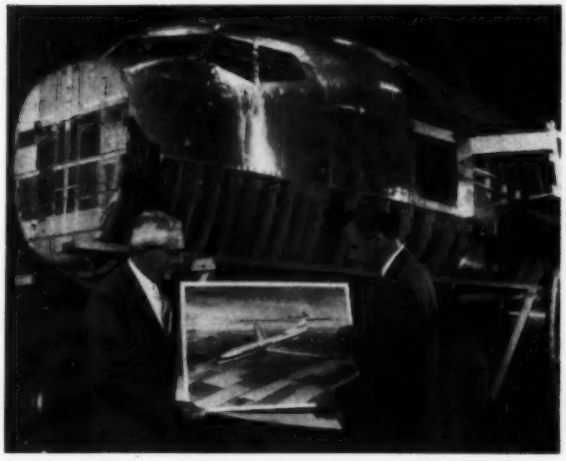
Arguments for placing *two* engines aft of the wing are, however, quite different. After many studies of two-engined layouts for their short-haul jet, Boeing concluded that, so far as safety, drag, and stability and control were concerned, there was nothing to choose between pod- and aft-mounted engines. Accessibility and the possibility of using identical nacelles (and existing ones) favoured the underwing pod. All other important considerations argued for rear mounting.

This weight of argument in favour of aft engines seems rather surprising, especially in view of Boeing's previous objections. But the general-arrangement sketch of the underwing-pod twin, the 727-265, reveals disadvantages inherent in the layout. (It is highly significant, incidentally, that all three engine arrangements have been offered to the US domestic airlines—twin-engined Convair 60, three-engined Boeing, and four-engined DC-9.) In the first place, reasonable asymmetric control demands that underwing pods be placed well inboard; but they restrict access to the nose-loading door while contributing nothing to wing bending-moment relief. In a four-engined arrangement only the outer pods contribute usefully to offsetting the aerodynamic bending load; most of the moment applied by the inner pods is offset by the extra structure that is needed to react the torsional loads imposed by the pods. With the two underwing-mounted engines slung in this fashion, the balance problem also becomes rather difficult, resulting in the hunched appearance of the -265 project shown in the sketch.

Other advantages claimed by Boeing for the rear-engine layout are: (1) engine intakes higher above the ground (less likelihood of debris ingestion and of pod-scraping on landing); (2) a saving in overall weight, amounting to 1,000lb-3,000lb on empty weight; (3) 3,000lb-5,000lb more second-segment climb weight; (4) more reverse thrust without the risk of flap blast or acoustical damage; (5) a quieter cabin; (6) a lower fuselage with less tendency to tip on to the tail (main wheels farther aft); (7) better access to equipment in the wing; (8) a better low-speed configuration and a better flap.

Following these conclusions, Boeing conducted a "parametric survey" to determine the configuration that would give the lowest operating cost for short/medium range routes with a field performance that would bring the jet to fields where only Martins and Convairs had operated before. The results strongly favoured a twin- or three-engined aeroplane, direct operating cost with a twin, for example, being eight per cent less on a 500-mile stage than with a four-engined design.

It may have struck the reader that all these studies were conducted by Boeing without reference to possible customers and, in fact, quite an advanced stage had been reached before the six major American airlines were included, in the summer of 1959, in a detailed airline-opinion survey.



Standing beside one of the full-scale mock-ups of the Boeing 727, and admiring the public relations department's rendering of their design, are Mr John O. Yeasting (left), vice-president and general manager, Transport Division, and Mr J. E. Steiner, 727 senior project engineer

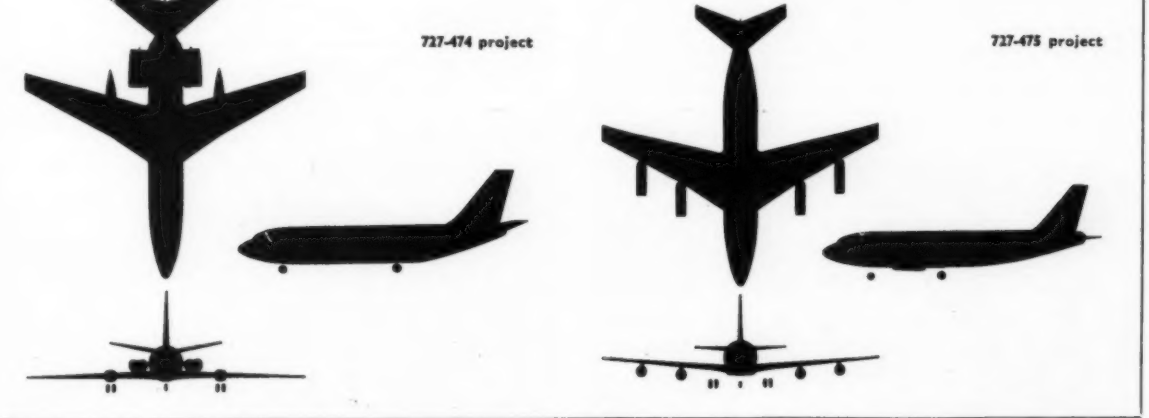
Influenced to whatever extent they might have been by British ideas for a three-engined short/medium range jet (DH Trident, Bristol 200 and Avro 740) Eastern, PanAm and Capital are believed to have specified three engines as a first choice. The other airlines—American, TWA, United and Braniff—had differing ideas on the ideal configuration, but all accepted a trimotor as a second choice; in other words, of seven US airlines, all were prepared to consider very seriously a three-engined layout for their short-haul jet.

Not all, of course, were potential purchasers, but UAL were certainly in the market, EAL probably were, and TWA would like to be. The other powerful voice in the domestic big four is American Airlines. The opinion survey also helped to crystallize ideas on numbers of seats and aerodrome performance: about 68 first-class seats, four abreast in a 148in (707-width) cabin;

PROJECT DIMENSIONS

	727-475	727-474	727-264C	727-265
Span	100ft 8in	100ft 8in	100ft 8in	100ft 8in
Overall length	102ft 1in	104ft 2in	104ft 2in	103ft 5in
Height	33ft 8in	36ft 0in	36ft 0in	33ft 8in
External fuselage width	12ft 4in	12ft 4in	12ft 4in	12ft 4in
External fuselage depth	12ft 8in	12ft 8in	12ft 8in	12ft 8in

The 727-474—essentially a four-engined variant of the 264C—was rejected, largely owing to apprehensions about "contagious" engine failure. It was followed by the 727-475, virtually a scaled-down 720 and known in the design office as the "720 Junior." As the table above shows, all four projects shared a common wing span and the Boeing 707/720 fuselage. The two aft-engined studies had a ventral passenger-door



Boeing's Trimotor . . .

1,000-1,600 st-mile range and a landing field length of 4,700ft to 5,200ft. American domestic fare levels really demand that if four-abreast seats are used for first-class, then six should be used tourist-class, since at five-abreast tourist-class revenue-rate is seven per cent down on first-class.

Between June and September, the Boeing 727 was argued-out with the airlines. Most were against four engines on the score of operating cost; TWA and United had a case to make for a 136in wide fuselage; others wanted much longer range. A strong case made against a twin-engined layout was the declaration by the FAA that, until it was demonstrated that other rulings could be adopted, twin jets would be subject to minima similar to those of twin piston-engined aircraft. At Idlewild, for example, these are 300ft and half a mile, compared to 200ft and half a mile for a three- or four-engined aircraft. Translated into annual delays, on just over 11,000 scheduled departures a year, the picture looks like this:—

	Two-engine	Three-engine	Difference
Departures delayed by one hour or more (per cent)	3.1	1.14	1.96
Annual delays of one hour or more (hr)	342.0	126.00	216.00
Departures delayed by more than 2hr (per cent)	2.0	0.34	1.66
Annual delays of more than 2hr (hr)	221.0	38.00	183.00

It was during the autumn of 1959 that the 727 emerged as a three-engined transport of about its present size and weight, and apart from the choice of powerplant—which still lay between Rolls-Royce/Allison and Pratt & Whitney—the design was finalized on September 18, 1959.

The wing has 32° sweep and less dihedral than the 707, so as to reduce Dutch roll. Simple dual-wheel main landing gear was adopted (the Trident is four-wheel) and the upper body above the chine is standard 707 production, except that the 10in × 14in window (as fitted to some 720s) and big doors—48in × 56in, larger than in any other 707—are standard.

Under the project number 727-323 a number of different three-engined layouts were studied, including a V-tail (rejected because of the possibility of fluid running into actuating units), a twin-fin arrangement and another with two pods under the wings and a pod on the tail. As Boeing point out, there are just so many places to put a third engine—all in the fuselage. Nor, as a matter of history, is aft mounting new to them, since some experimental installations were made on a B-47 about 15 years ago.

So the 727 grew a third engine in the tail, and the tailplane was raised to a T-position to keep it clear of the wash of the very big, triple-slotted flaps that give the aircraft its field performance, and the fin was extended to increase the arm and keep the tail light. These changes gave rise to charges that Boeing had copied the Trident, and they are a little sensitive about this. But they are more seriously concerned at being charged with copying the Caravelle, since Sud have a very good patent (2,863,620) protecting just the three-engine arrangement adopted by both Boeing and de Havilland—as well as bifurcated intakes in each side pylon for good measure.

Boeing offered two engines: the Rolls/Allison AR 963 (RB.163) of 12,750lb thrust and, subsequently, the new Pratt & Whitney JT8D, commercial version of the J-52. This latter engine has run 13,500hr, completed 325hr flight running and has passed its 150hr production test. Perhaps for this reason, perhaps because an operator prefers a home to an overseas design, both Eastern and United have chosen the Pratt & Whitney engine although, as a P & W man told *Flight* in New York: "Rolls-Royce are a *very* tough competitor."

The central engine is suspended from an overhead beam, and is accessible from underneath or on either side via hinged cowling panels which divide on to the aircraft's lower centre line. The hinge pins can be removed and the complete cowling detached when required. Carried with the aircraft is a special portable hoist, which picks up on two points on the port side of the fuselage just above the engine; this tool can be used to carry out an engine change if proper ground equipment is not available.

The same two-door type thrust reverser is used on all three engines, exhausting horizontally from the central engine and vertically for the two side units. Fan flow is mixed with the turbine efflux in the JT8D so that a common reverser is possible. The actual unit will be a modification of the JT4 suppressor, about 90 per cent common with that in the 707. Cascade vanes will not be used, and it is hoped to achieve a reverse efficiency of 50 per cent. At the same time, with good hot/cold flow mixing and compressor sound-absorbing panels in the inlet duct, Boeing hope to reduce noise below present levels.

The short-haul nature of the 727 makes its manner of use in local service worth considering. While the normal passenger rear ventral entrance is by 33in-wide retractable stairs, like the Caravelle, Eastern have bought for their aircraft a retractable stair for the front steps, which folds up *under* the normal floor. The middle engine can be kept turning during ultra-short turn-rounds, and in any case vapour-cycle air conditioning and a.c. electric starting are to be used to reduce turn-round time. The starting technique, in which the alternator and Sundstrand drive are used as a synchronous motor and variable-ratio starting gear-box, is most interesting, as it is the first practical example of a system believed to have been pioneered in Great Britain two years ago. Other aids to rapid turn-round are a single-point refuelling system through which fuel can be delivered at 600gal/min; fore-and-aft carry-on baggage racks; a separate galley loading door; and a relatively high landing weight.

In all respects, the Boeing 727 offers stern competition to the D.H. Trident. But in the matter of automatic flare-out and automatic landing, even of fully integrated autopilot systems, the 727 apparently offers nothing more than its predecessors. The current feeling at Boeing seems to be that autopilots are difficult and complex enough without trying to duplicate or triplicate them to serve additional super-reliant functions (see *Flight*, November 25, page 840) beyond a possible single-channel, "pilot take-over" landing system. Only in one respect has any concession to later developments along these lines been made; the flying controls are now powered and duplicated. But manual reversion has been retained—an engineering expedient unthinkable to most British engineers in this year 1960.

* * *

The following table is a revision of that published on page 938 of *Flight* for December 16, which it supersedes. The table compares the time-scales of the Boeing 727 and the D.H. Trident Mk 1, and it shows that, though Boeing committed themselves to their project much later than de Havilland did to the Trident, D.H. concedes nothing to Boeing in the speed with which their programme is being implemented. It is generally agreed that the Government's political intervention over BEA's order in 1957 wasted a whole year; on the other hand, approximately one year (February 1958—February 1959) was spent on the design of an aircraft that had to be revised because it had grown too large for BEA's requirements. But, using as the criterion the time taken from start of design to first delivery, it will be seen that the Trident time-scale is *exactly* the same as that of the Boeing 727:—

COMPARATIVE TIME-SCALES

	Boeing 727	D.H. Trident Mk 1
Initiation of project studies	Summer 1956	Summer 1956
Start of final design	September 1959	February 1959
First flight	October 1962*	December 1961
First delivery	January 1964	June 1963†
Start of final design to first flight ...	3 years 1 month	2 years 10 months
First flight to delivery	1 year 3 months	1 year 6 months
Start of final design to delivery ...	4 years 4 months	4 years 4 months‡

*"Autumn 1962." †"Mid-1963." ‡Say 3 years 4 months if allowance is made for political intervention in 1957.

FORTHCOMING EVENTS

Jan. 3. RAeS Astronautics and Guided Flight Section: "Planning of Missiles Acceptance Trials," by J. F. W. Mercer and A. R. Cawthorne.

Jan. 4. BritIRE (Radar Group): "Automatic Techniques in Civil Airline Communications Systems," by W. E. Brunt.

Jan. 5. RAeS: Young People's Lecture, "Gyroscope and Pendulum—the Modern Travel Agents," by R. J. Lees.

Jan. 6-7. RAeS (joint meeting with College of Aeronautics and BIS at Cranfield): Rocket Propulsion Symposium.

Jan. 9. RAeS Historical Group: "Rebuilding and Flying Historic Aeroplanes," by Air Cdre A. H. Wheeler.

Jan. 11. BritIRE (South Wales Section): "The Measurement of Ionizing Radiation," by R. G. Wood.

Jan. 11. BritIRE (West Midlands Section): "An Equipment for Automatically Processing Time-multiplexed Telemetry Data," by N. Purnell and T. T. Walters.

Jan. 12. RAeS: "The Law and Science in Aeronautics," by H. Caplan.

Jan. 12. Institute of Metals: "Metallurgical Research at High Pressures," by Dr J. E. Hilliard.

Jan. 13. RAeS Rotorcraft Section: a.g.m. and "Certification of Civil Transport Rotorcraft with Particular Reference to Multi-engines," by H. E. Le Sueur.

Jan. 13. Society of Instrument Technology (Midland Section): "Controls Associated with Flying," by Capt A. M. A. Majendie.

RAeS Branch Fixtures (to Jan. 6): Jan. 2, *Derby*, a.g.m. and lecture. Jan. 4, *Bristol*, "Bird Flight," by J. L. Naylor; *Brough*, "Problems of Rocket Engine Development," by A. V. Cleaver; *Christchurch*, "The Wind-excited Oscillations of Suspension Bridges," by D. E. J. Walshe; *Hatfield*, "The Development of the Aircraft Carrier," by Capt Short and Lt-Cdr Barlow; *Reading*, "Hovercraft Development," by W. J. Eggington; *Swindon*, a.g.m. and films; *Weybridge*, "An Experiment in Vertical Take-off," by D. Keith Lucas (at RAeS new lecture theatre). Jan. 5, *Isle of Wight*, a.g.m. and film show.

Who Designed the Famous Sopwith Types?

A MYSTERY SOLVED BY . . .

Wg Cdr NORMAN MACMILLAN, OBE, MC, AFC

The Sopwith Pup

WHEN I set out to write *Great Aircraft* I found myself bedevilled by questions of historical fact to which I could find no answers through orthodox methods of research. Many other writers on the earlier periods of aviation must encounter similar difficulties—problems not made easier by the number (still increasing) of incorrect accounts of men, machines and events. I have just read a recently published book of the First World War in the air which is full of inaccuracies.

One of my particular problems was: who designed the Sopwith Camel? I searched through all contemporary copies of *Jane's All the World's Aircraft* and aeronautical journals and found no clue. None of the aeronautical bodies was able to answer the question. So I wrote to Sir Thomas Sopwith and asked him. He replied that it was a long time ago and memory was unreliable at such long range; he could not say whether it was "before or after Smith joined the company"; but if it was before (and he thought it was) then the Camel was designed by himself, Sigrist and Hawker in collaboration.

My next step was to find out when this Mr Smith joined the Sopwith company. But there again I drew blank with all the reference books and periodicals of the period. I did not even know the gentleman's initials or Christian names and I doubted if Sir Thomas Sopwith would remember them; so I did not trouble him with the question, particularly as he was by now abroad.

Frank H. Smith, the librarian of the Royal Aeronautical Society, unearthed through *Flight* that the name of the chief designer of the Hawker Engineering company at the time of the take-over of the dissolved Sopwith company was Captain B. Thomson (*circa* December 14, 1922, issue of *Flight*). Two-and-a-quarter years later *Flight* reported: "Mr Carter, the firm's chief designer . . . ably seconded by Mr S. Camm." The 1951 issue of *The Aeroplane Directory* listed Wilfred George Carter, CBE, FRAeS, as the technical director of Gloster Aircraft Co Ltd; his notice stated that he joined the Sopwith Aviation Company in 1916 as chief draughtsman and that he was appointed chief designer when the firm became the Hawker Engineering Co, for whom he designed the Heron and Hornbill single-seat fighters and the Horsley day-bomber. He later became historically famous as the designer of the Whittle turbine-engined Gloster E.28/39 flight-tested in May 1941. In the same reference work I found that Mr (now Sir) Sydney Camm, CBE, FRAeS, became chief designer of Hawkers in 1925.

But still no clue turned up to locate Mr Smith! Conflicting information came to me from various sources, with numerous surmises and inaccurate dates (as I subsequently proved them to be). Then I learned that Mr Smith's initial was "E." This later proved wrong. It was H for Herbert. In the end it was Mr Alexander Johnston, head of the SBAC Information Department, who discovered and gave me the correct name and address of Mr Smith and I was able to make contact with him. The result was an interesting piece of aeronautical history, which deserves its place in the record, for I cannot say where else it may be found but here.

Herbert Smith took a Diploma in Engineering at the Bradford Technical College, then spent three years in a workshop and one year in a drawing office before joining the Bristol Aeroplane Company as a draughtsman. He transferred to the Sopwith Company in March 1914, also as a draughtsman, and was there until their liquidation in October 1920.

When he first joined Sopwiths (he told me) they had no designer. The chief draughtsman, Mr Ashfield, had been a school teacher and carried out instructions from Sopwith, Sigrist and Hawker. These three were largely responsible for the 1½-Strutter, the Pup and the Camel, the last two being derivatives of their pre-war Tabloid.

Mr Smith recalled having seen the Tabloid at one of the flying meetings at the London Aerodrome, Hendon, in 1913. With a 50 h.p. Gnome engine it did about 80 m.p.h., which he thought very good considering the engine developed only about 38 h.p. He told me he imagined that nearly all pre-1914 machines were produced from full-size chalk drawings, a procedure he himself saw in operation. (The earliest aviation "lofting" process.) When he joined Sopwiths they were building the Bat Boat and a float-plane with 200 h.p. Canton Unné engines, which never passed much beyond the experimental stage.

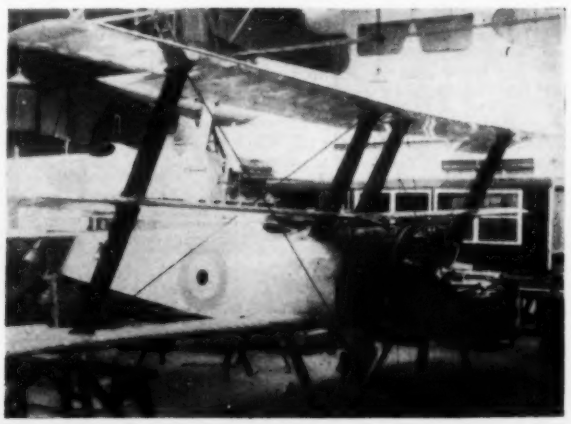
From Mr Smith's evidence it became certain for the first time that the Camel was the brain-child of the famous trio: Sopwith-Sigrist-Hawker. In November 1914 Herbert Smith took complete charge of new design (as distinct from continuity development) and was responsible for the 110-130 h.p. Clerget-powered Triplane, the 230 h.p. B.R.2-engined Snipe, the Salamander armoured single-seat trench fighter, the two-seater armoured Buffalo trench fighter and contact patroller, and the 200 h.p. Hispano-Suiza-engined Dolphin.

The Clerget Triplane was started on April 18, 1916, and was tested on May 30—six weeks for construction, surely a record even for those days! The Sopwith company built two other single-seat triplanes, one fitted with the Hispano-Suiza engine, and another—the Snark—with a 320-360 h.p. ABC Dragonfly; there was also the three-seater Cobham triplane bomber with twin Dragonfly/Puma engines as further tributes to Mr Smith's versatility in design. He was responsible, too, for many other types which did not go into quantity production. He recalls that Harry Hawker used the 110 h.p. Le Rhone Camel-fuselage high-wing monoplane called the Swallow as a runabout.

After the liquidation of the Sopwith Aviation Co Ltd Mr Smith went to Japan as designer to Mitsubishi, returning to England in June 1924, when Hawker Engineering invited him to rejoin them as designer and Vickers approached him to join their newly formed Canadian company.

Dolphin four-gun fighter

Triplane (in the old skating-rink works)



F.II

F.III

F.IV

FORTY YEARS O

From F.II to F.27 Friendship

FORTY years ago an entirely new type of airliner made its first appearance in service, when KLM Royal Dutch Airlines, founded a year before, introduced the Fokker F.II on their daily service to London. The F.II aroused particular attention because it was one of the first aircraft to have been designed from the outset for transport purposes.

The man who designed and built the F.II was 30-year-old Anthony Fokker. In Germany during the war he had built thousands of fighters for the German forces, and had then returned to his homeland, taking trainloads full of completed aircraft and factory equipment with him. In the summer of 1919, shortly after his repatriation, Fokker founded his Dutch company, which eventually occupied the halls erected for the ELTA aviation exhibition in the northern part of Amsterdam. Here Fokker started work with the conversion of military aircraft for the Dutch and other forces, and in later years many successful types of military aircraft left these halls for delivery to countries all over the world. Between the wars, however, he became best known for civil airliners, of which the F.II was the first of a long and famous line.

While still in Germany Fokker had been thinking of the possible use of aircraft in peacetime, notably for the transport of goods, mail and even passengers. Accordingly he designed a high-wing monoplane with a cabin for four passengers, giving it the designation V.45—V standing for Versuchsbau, i.e., experimental type. Construction was started immediately after the war, and the aircraft was successfully flown. Once Fokker had decided to return to Holland it was ferried to Soesterberg by his Dutch test pilot Bernard de Waal.

Back in Holland Fokker adopted a new system of designation for his aircraft, giving his commercial airliners numbers preceded by the letter F. Thus the V.45 became the F.II (F.I had been allotted to an earlier type which was never built). KLM ordered two F.IIs, which were delivered in September 1920 and placed in service on the Amsterdam - London route. The F.II was almost immediately followed by the somewhat larger F.III, seating five passengers instead of four. A remarkable feature of the F.III was that the pilot—who, like his colleague in the F.II, had an open cockpit—was emplaced not behind the engine but beside it and could thus effect simple repairs in the air. A total of 34 F.IIIs was built by Fokker, 14 of which went to KLM; others were for Deruluft and Malert (Hungary). The German Grulich company built both the F.II and F.III under licence and supplied numbers of these aircraft to the two German airlines—Deutsche Luft Reederei and Deutscher Aero Lloyd.

The F.III in its turn was developed into the larger F.IV—intended mainly for the American market, Fokker having designed it after his return from a visit to the USA. Two F.IVs were built and shipped to America; but although this 11-seater was an excellent aeroplane the US operators of that time (whose business was still in its very early stages) showed little interest. The two F.IVs were then sold to the US Army Air Corps under the designation T-2, one later being converted into an ambulance and designated A-2. With the T-2 Lts MacReady and Kelly set up a world duration record of 36hr; they also established a new coast-to-coast record by flying from New York to San Diego in 26hr 50min. This particular F.IV can still be seen in the Smithsonian Institution in Washington.

An aircraft of an entirely different configuration was the F.V, built in 1923, which could be flown either as a biplane or as a monoplane. Its fuselage was of steel-tube construction covered with plywood, and the eight-seat cabin was heated from a muff placed round the exhaust pipe. Only one of the type was built; later it was sold to Austria.

The designation F.VI having been used for a fighter developed for the USA, Fokker's next airliner became the F.VII. Specially designed in the light of Dutch plans for a flight to the East Indies, it was in the first place a long-range aircraft. Standard Fokker construction—a wooden wing of thick section and a fabric-covered steel-tube fuselage—was employed. The undercarriage, a remarkable system of steel tubes, was particularly robust. With the first F.VII Capts Van der Hoop and Van Weerden Poelman, with engineer Van den Broeke, left Amsterdam on October 1, 1924, to fly to Batavia (now Djakarta), the capital of the Dutch East Indies, which they reached on November 24 after engine trouble had grounded them for three weeks near the Bulgarian town of Philippopel. On the advice of Mr H. Grasé, BSC, one of Fokker's engineers, and also on that of his chief test pilot, the F.VII (five of which had meanwhile been built) was extensively modified in 1925 to become the F.VIIa. This had a redesigned wing form and a much simpler undercarriage, and is said to have been the first airliner fitted with an air-cooled radial engine (a 400 h.p. Bristol Jupiter). The F.VIIa proved to be an excellent aircraft and production was well under way when Fokker went out once again to the USA.

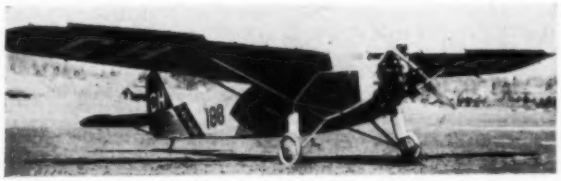
The Ford Reliability Tour having been announced, Fokker decided to participate, seeing in this competition a good opportunity to introduce his aircraft to the Americans. From the standpoint of reliability a single-engined machine did not seem to

F.V

F.VII

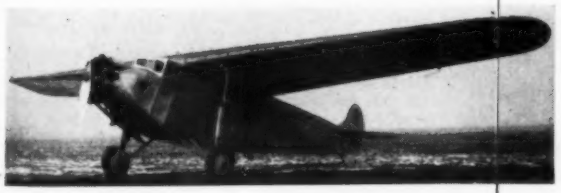
OF FOKKER AIRLINERS

By B. VAN DER KLAAUW



F.XI

F.XII



F.XIV

Fokker to be altogether desirable, so he cabled instructions to Amsterdam for the conversion of a single-engined F.VIIa into a three-engined machine by the addition of two engines under the wing. All three engines were Wright Whirlwinds. Back in Amsterdam again two months later—in September 1925—Fokker himself made the first test flight of the new model. Proving satisfactory, the aircraft was immediately packed and shipped to the States. Fokker and another pilot flew the machine in the Ford Tour, covering a distance of 1,900 miles in slightly over 18hr with seven passengers and a useful load of 500lb. The three-engined F.VIIa emerged as the winner and the tour was renamed by the American public the "Fokker Publicity Tour."

The victorious aircraft was soon afterwards purchased by Admiral Byrd, who used it for his flights to the North Pole.

F.VIIIa

Left, F.VIIb/3m

More F.VIIa Fokkers, both single-engined and three-engined (F.VIIa/3m) were built, to be followed by a new version with a larger wing—the F.VIIb/3m. Meanwhile Fokker had firmly established himself in the USA and the F.VII version he built there became known as the Fokker Trimotor (C-2). Only the fuselages for these aircraft were built in the USA, the wings being constructed in Amsterdam and shipped out for final assembly. In Europe Fokker built 116 aircraft of the various F.VII models (mainly F.VIIb/3ms), and they were built under licence by A. V. Roe in Britain, by Sabca in Belgium, Officine Ferroviari Meridionali in Italy, Plage & Laskievics in Poland, Avia in Czechoslovakia, and Manfred Weiss in Hungary. The Polish factory also built a number of bomber versions.

Many famous flights were made with F.VIIs, and several machines of the type gained world fame—such as Kingsford Smith's *Southern Cross*, Byrd's *America*, the Duchess of Bedford's *The Spider*, and Van Lear Black's *Maryland Free State*. A special floatplane version was supplied to Amelia Earhart, who called it *Friendship*, a name which is perpetuated today in the Fokker F.27. Even until a few years ago F.VIIs could be found in service somewhere or other.

The year 1926 saw the emergence of the F.VIII, the first twin-engined airliner designed by Fokker. It was a relatively short-range aircraft, seating 15 passengers, and the two engines were hung under the wings, as on the F.VII, though later one F.VIII was modified to have its engines set in the leading edge, this version being known as the F.VIIIa. It was used by KLM for air survey. Fokker built seven and Manfred Weiss built additional ones for Malert. A number of ex-KLM aircraft eventually served with British companies.

In 1928 came the F.IX, a big brother of the F.VII and intended for KLM's Far East services. Although 17 passengers could be accommodated, only four to six were provided for—in quite a comfortable way—on the Far East run. The F.IX, however, did not meet KLM's requirements, and only two were built. Avia in Czechoslovakia constructed the type under licence as the Avia F-39, and supplied these machines as bombers to the Czech and Jugoslav Air Forces.

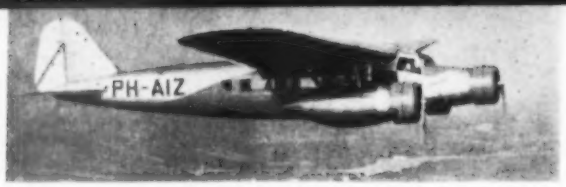
A much smaller aircraft was the F.XI—not to be confused with the US-built Universal, which was also known as the F.XI. The Dutch-built aircraft was really an air taxi for four to six passengers, and a special feature was the wing, which was built in two halves and attached to the top longerons in shoulder position. Only one was built and this was supplied to the Swiss company Alpar. Astonishingly, this machine is still flying in Austria, recently having reached its 30th year of continuous operational service. Later two slightly enlarged versions were built for Malert.

Greater success was achieved with the F.XII, a modernized development of the F.VII/3m family. Originally it had an undercarriage with wheel fairings, but these were later omitted. Fokker built eleven of these machines, mostly for KLM, and the Danish Orlogsvaerfted built two for DDL. Quite a few ex-KLM F.XIIs were later sold to Britain.

A "one-off" was the F.XIV, originally built as a single-engined freighter. Although based on the F.VII series, it was in fact an entirely new aircraft. The airlines, however, seemed to have little enthusiasm for a pure freighter, so the type was converted into a three-engined passenger aircraft seating eight. Unsuccessful, it ended its days as an exhibit in a pleasure garden.

A better known type was the F.XVIII, five of which were built in 1932. An improved F.XII, it was used by KLM with great success on their Far East service. One, *Pelikaan*, flew in December 1933 from Amsterdam to Batavia in four days and made the return trip in about the same time. Another, *Snip*, flew to the Caribbean in December 1934. The F.XVIII normally seated fourteen, though on the Far East route only six were carried. Simultaneously with the F.XVIII Fokker built the F.XX, a greatly modernized and streamlined development of the famous three-engined series, featuring a retractable undercarriage. It was not successful in operation, however, and after a short time KLM sold it to France.

The last of Fokker's pre-war airliners were the five giants—one F.XXXVI and the four F.XXIIs. An interesting point about the



F.XX

F.XVIII

F.XXII

F.36

Forty Years of Fokker Airliners . . .

designations is that they signified the number of passengers that could be carried. Both types were of mixed construction and, although it was intended to use them on the Far East route, the plan was never implemented and they were employed only within Europe. Of the four F.XXIIs one was sold to the Swedish company ABA, and in 1939 KLM sold three to Scottish Aviation, the last of which remained serviceable until 1953, when it was broken up.

Meanwhile, things were changing. In the USA Boeing had introduced its all-metal Model 247, which was followed by the Douglas DC-2. These types immediately proved very popular among the travelling public and the late Albert Plesman, president of KLM, wished to be the first to introduce something of the kind into Europe. He contacted Anthony Fokker, asking him to build all-metal aircraft of this sort for his company. Fokker replied that the changeover from his famous wooden construction to all-metal would take some time—too long, in fact, for Mr Plesman to wait, so the latter decided to order the airliners he needed directly from the USA. Other airlines in Europe and elsewhere soon followed KLM's example, and Fokker quickly realized that he had lost the game: from then on there would be no further market for his traditional type of airliner. He therefore decided to concentrate on military types such as the twin-boom G.I, which stole the show at Paris in November 1936. The construction of an airliner, however, was never out of Fokker's thoughts. He had meanwhile obtained production and sales rights for Europe for the Douglas airliners, but no orders of sufficient size were received to justify production in Europe. Not until 1939 did Fokker release details of a twin-engined high-wing airliner carrying 24 passengers and designated F.24. Not unlike the Douglas DC-5 in general arrangement, it appeared to have real promise, and in the late summer the company announced with elation that a KLM order for four F.24s had been received. Then, on December 23 of that year, came news that Anthony Fokker had died in New York after a short illness. Five months later German soldiers occupied his buildings in Amsterdam.

When, in post-war years, the Fokker company decided to re-enter the commercial field (meanwhile having established a very creditable record of military-aircraft production), it had become clear that the construction and development of large four-engined airliners would be beyond the capabilities of Holland's aircraft industry. It was decided, therefore, to concentrate on a DC-3 replacement. During 1951 all DC-3 operators were asked about their particular requirements; but Fokker could still not decide on the shape and size of the required aircraft. For several reasons—not the least because it would continue the old Fokker tradition—a high wing was eventually chosen. Originally it was planned to build prototypes with both piston engines and turboprops, but later it was decided to construct only the latter version, and two Rolls-Royce Darts were selected as the standard powerplant. When, in 1952, investigations indicated that there were good sales prospects for the aircraft—meanwhile numbered F.27 and named Friendship—construction of four prototypes was begun. The Dutch Government, through the National Aircraft Development Institute (NIV) provided the necessary funds for the early development work.

KLM ordered two aircraft to start the production line. Four prototypes were ordered—two to fly, one for structural tests and the fourth for fatigue tests; the first made its maiden flight on November 24, 1955.

Of the greatest importance to the Friendship's success was the licence agreement concluded in April 1956 with Fairchild in America. Fairchild was authorized to build Friendships and was granted sales rights for the Western Hemisphere, excepting Brazil, where Fokker had its own subsidiary. The granting of a US Type Certificate on October 29, 1957, was another big step on the way to success in the American market.

Fairchild delivered its first Friendship to West Coast Airlines on June 22, 1958, and Fokker's first delivery abroad was to Aer Lingus on November 19 of the same year. Recent orders from the German Lufttransport Unternehmen and from Sudan Airways have brought Fokker's total to 85 Friendships firmly ordered, plus a number of options. When taken up, these options will bring Fokker beyond the reported break-even figure of 100 aircraft. Fairchild production is almost complete, with 83 orders received. By the end of September this year more than 110 Friendships were in service and had logged some 225,000 flying hours.

Development continues. Already versions for executive use (Friendship de Luxe) and for a military transport (Troopship) are being developed and have sold in small numbers. On these, as on the Fairchild-built version, a nose radome will henceforth be standard equipment. The first prototype Friendship has recently been fitted with double trailing-edge flaps, thus creating what the company's chief designer, Mr H. C. van Meerten, calls a "short-field version." Similar flaps were incorporated in the first aircraft when it first flew, but it was found that they had an unfavourable influence on longitudinal trim. An adjustable tailplane is now fitted, coupled with the flap mechanism, and elevator area has been increased by 20 per cent. With a gross weight of 37,500lb, take-off run should be about 720ft, and distance to clear 50ft about 1,250ft. Landing ground-run should be 885ft. This performance with an almost standard Friendship renders the aircraft very attractive from a military standpoint, and Fokkers are offering a military short-field version powered by two Rolls-Royce Dart RDa.8s.

Development of a stretched version of the Friendship is also under way, this having a fuselage lengthened by about 7½ft and seating eight more passengers. Take-off weight will be 42,000lb. Eastern Air Lines is reported to have been contemplating the purchase of 30 of these 48-seaters powered by Rolls-Royce Dart RDa.10s, and interest is likely to be taken by the USAF, which still needs a replacement for its many C-47s.

Thus the story of the Fokker airliners is by no means at an end. On the contrary, there is hope that it will continue for many years to come.

Friendship with F.VIIa

A pair of J 35A intercepters from wing F13 of the Royal Swedish Air Force race like arrow-heads across the azure sky

SAAB

Sweden's Advanced Combat Aircraft

SAAB stands for Svenska Aeroplan Aktiebolaget, or Swedish Aeroplane Company. Saab are unique in several respects, and it is appropriate at this time to cast an eye over their operations. In doing so it is well not to forget that Sweden is strictly neutral, being neither Communist nor a signatory to the North Atlantic Treaty. Perhaps for this very reason the Swedes have been singularly steadfast in their policy-making; and Saab have yet to suffer cancellation of any major programme.

To some extent, of course, this is because they have taken care not to bite off more than they can chew. Their primary function has always been to design and build military aircraft for the defence of Sweden. Although the Royal Swedish Air Board has frequently put aircraft of foreign design into squadron service—the last major example being the Hunter—it has always striven to be as self-sufficient as possible, and the burden of responsibility on Saab has not been light. To meet the challenge the company have produced a succession of three single-jet combat aircraft which stand up well in comparison with any contemporary design. These are the Saab-29, first flown on September 1, 1948; the Saab-32, first flown on November 3, 1952; and the Saab-35, first flown on October 25, 1955. The remainder of this article is concerned chiefly with the two last-mentioned, which are respectively known as the Lansen and Draken. But first it is worth commenting on the firm as a whole.

Saab's headquarters are at Linköping, just over 100 miles south of Stockholm. Employment here is approximately 4,900, out of a total payroll for all plants and subsidiaries of about 8,400. In November 1959 a new factory was opened at Trollhätten increasing the company's output of cars to about 40,000 a year; and it is worth noting that a Saab 96 won the recent RAC Rally, even though it had a smaller engine than any other competitor. Saab are at work in the data-processing field, and also make autopilots and fire-control systems for guided weapons, although details remain classified. Other aviation work includes the production of the Alouette 2 under licence from Sud; the Helicopter Division at Norrköping are delivering these machines to the three Swedish armed services, and are about to switch to the Alouette 3. Production of the Saab-91 Safir continues; well over 300 have been sold to several air forces and civil schools, and last month the first nine of an order for 15 were flown out to Tunisia. Saab have abandoned the 94 twin-engined version of the Safir and the Saab-105 medium transport.

LANSEN AND DRAKEN

Saab-32 Lansen In the autumn of 1946 Saab began to study designs suitable for replacing the Saab-18B as the standard RSAF attack aircraft. After two years of studying a twin-Ghost project the company turned to a design with a single more powerful turbojet, and on December 20, 1948, a Phase-1 (design and mock-up) contract was placed for a tandem-seat aircraft primarily intended for attacking land and sea targets under all weather conditions or at night. More than 2,000,000 man-hours were required to complete the engineering development, hundreds of research and rig programmes being involved.

Originally the Saab-32 was intended to be powered by the indigenous STAL Dovern turbojet, but the Swedes eventually decided not to proceed with the development of their own engines and Svenska Flygmotor commenced licence-production of the Rolls-Royce Avon 100, designated RM.5, with Svenska afterburner. Although a scaled version of the Saab-32 wing was flown on a Safir, the large slats of the first prototype are replaced in the production aircraft by fences. Ailerons and elevators are operated by hydraulic boosters, and the tailplane has variable incidence. All Saab-32 versions have search and navigation radar, and a pressurized and refrigerated cockpit.

First deliveries of the Saab-32A were made in December 1955. As the A 32A this aircraft equips all 12 attack squadrons of the RSAF, carrying four 20mm guns and either a pair of Robot 304 attack missiles or a wide variety of tanks, bombs or rockets. Delivery of the "several hundred" aircraft involved was completed by mid-1958, and production switched to the two succeeding versions. Largely redesigned in detail, the J 32B is an all-weather and night fighter, which first flew on January 7, 1957. Level speed and rate of climb are enhanced by the fitting of an RM.6B, a Swedish variant of the Avon 200, with an enlarged afterburner. A new navigation and radar fire-control system is fitted, together with four 30mm guns. External racks are provided for the same loads as those carried by the attack version, although the most usual stores are Rb 324 Sidewinder air-to-air missiles. Six squadrons are equipped with the J 32B. The third variant is the S 32C, which first flew on March 26, 1957. This reconnaissance version, which equips five squadrons, can fulfil a wide variety of reconnaissance missions by day or night. The last Lansen, a J 32B, was delivered in May of this year.

Saab-35 Draken In 1949 the RSAF outlined a requirement for an intercepter capable of destroying "bombers in the transonic speed range." Initially the requirement called for a Mach range of 1.4 to 1.5, but in 1956 the sights were raised to M1.7-1.8. Saab were asked to produce an aeroplane flown by a single pilot yet capable of operating under all kinds of weather or at night from relatively small airfields while carrying all the equipment needed to destroy modern jet bombers. Preliminary studies suggested that most of the critical problems posed by the requirement could be solved by adopting a delta configuration. But in order to obtain an aerodynamically correct c.g. location, the forward fuselage had to be extended and the aircraft became unnecessarily heavy. The optimum solution was found in the "double delta." Such a wing was then unknown, and the Draken design staff—led by Mr Erik Bratt, and eventually numbering more than 500 technicians—decided to build a small jet aeroplane with which the behaviour of the new wing could be explored.

In describing the Draken it is difficult to decide what constitutes fuselage and what can more properly be regarded as part of the wing. Essentially the fuselage has a circular section, and the inboard portion of the wing is the large-chord surface extending aft of the engine intakes, with a leading-edge sweep angle of no less than 80°. It was found possible to dispense with a tailplane, and the overall design is one of extraordinary cleanliness.

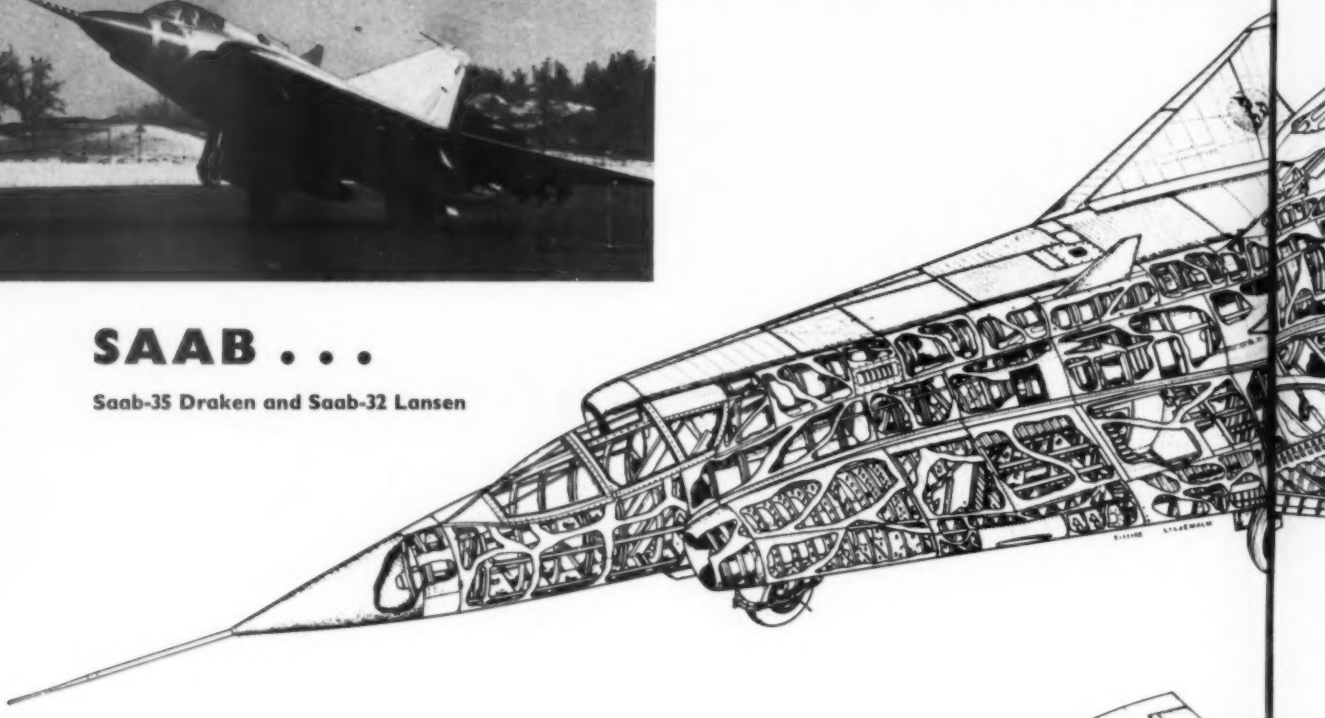
The fuselage consists of front and rear portions joined by bolts. The forward section, integral with the intake ducts and related wing structure, accommodates the radar fire-control, cockpit, nose undercarriage, integral tanks and various systems. The rear portion, manufactured as a unit with the rest of the inner wing, contains the engine and afterburner, bag tanks, armament, main landing gears and remaining systems. Bolted joints are used to attach the outer wings, each of which has skins machined from thick sheet. The control surfaces consist of a rudder and inboard and outboard elevons, the outer sections having mass-balance weights. Each surface is operated by a tandem hydraulic jack, the two chambers of which are connected into separate hydraulic circuits. There is no feedback, stick forces being generated by a Mach/q-feel system. A three-axis autopilot is fitted. To save weight, the hydraulic systems operate at a line pressure of 2,987lb/sq in—which, although comparable with Western practice, and appreciably below the 4,000lb/sq in of the Britannia, is more than double the pressure used in the Saab-29.

Following the flight of the first prototype in October 1955, an unusually intensive flight-test programme was required to explore the exceptional speed range and complicated systems; and, in spite of the utmost miniaturization, the airborne instrumentation in the first prototype weighed approximately 1,100lb. Gradually the first operational version, designated J 35A, became a reality; quantity production of this version was ordered in 1956 and the

Although primarily an intercepter, the J 35B can carry a wide range of anti-surface weapons (left, twelve 13.5cm rockets and a pod housing nineteen 7.5cm rockets). The J 32B Lansen can also carry a heavy external load, but is depicted (far right) in clean configuration

SAAB . . .

Saab-35 Draken and Saab-32 Lansen

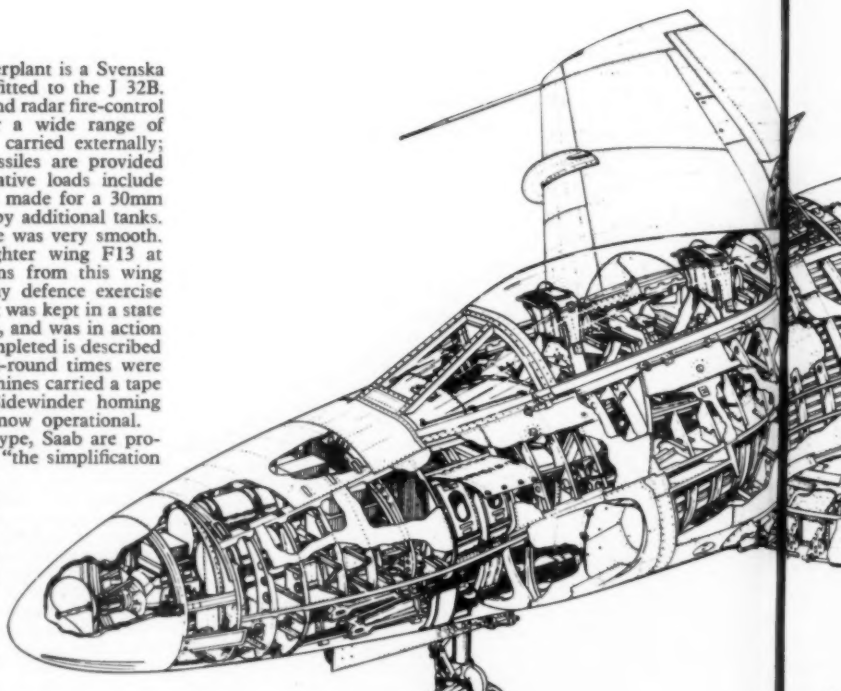


first off the line flew in February 1958. Powerplant is a Svenska Flygmotor RM.6B, almost identical to that fitted to the J 32B. The J 35A is equipped with the S.6 infra-red and radar fire-control equipment, making the aircraft suitable for a wide range of interception missions. Primary armament is carried externally; launchers for four Sidewinder air-to-air missiles are provided beneath the wings and fuselage, and alternative loads include a variety of bombs and rockets. Provision is made for a 30mm gun in each inboard wing panel, replaceable by additional tanks.

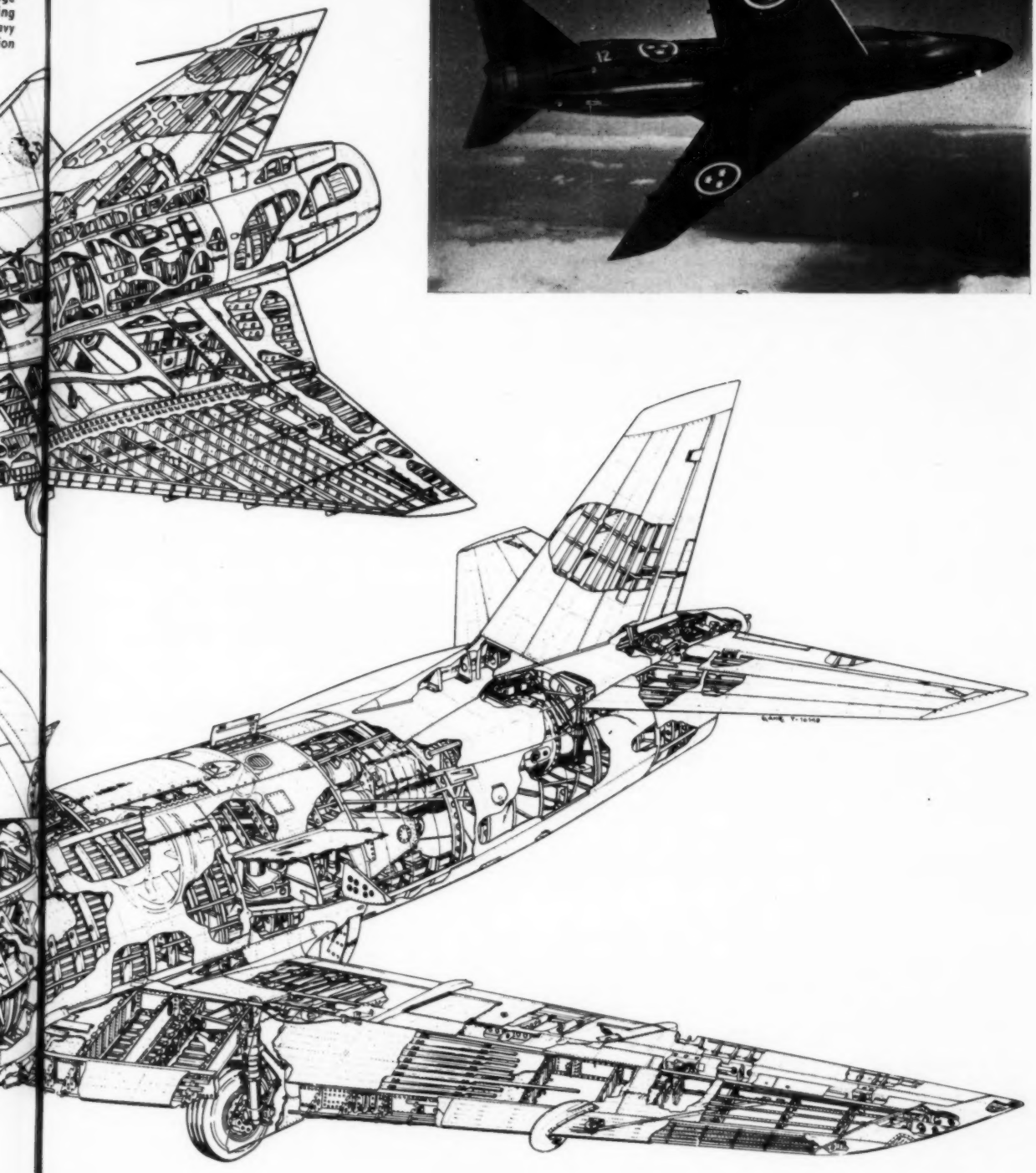
Introduction of the J 35A to RSAF service was very smooth. At the end of 1959 deliveries began to fighter wing F13 at Norrköping, and a small number of Drakens from this wing participated with great success in a three-day defence exercise concluded on March 20 last. The Draken unit was kept in a state of "highest readiness" throughout the exercise, and was in action by day and night. The number of missions completed is described as "very large," and both scramble and turn-round times were regarded as most satisfactory. One of the machines carried a tape recorder registering the behaviour of the Sidewinder homing heads. Several wings of J 35A aircraft are now operational.

In order to assist pilots converting to the type, Saab are producing small numbers of J 35C trainers. By "the simplification of certain equipment" additional space has been made available for a tandem cockpit, the instructor's Saab ejection seat being behind and above that for the pupil. The new forward fuselage has been designed for rapid replacement by that of the J 35A, the remainder of the aircraft being identical. The J 35C first flew a year ago today (December 30), and production trainers are now in service at a centralized school, which will also have the use of a flight simulator that is shortly to be delivered to it by Curtiss-Wright.

Most important version of the Draken is the J 35B, representing a natural outgrowth with improved performance and equipment. Powerplant of the new Draken is the Rolls-Royce RB.146, for which Svenska Flygmotor have produced a yet larger afterburner, the rear end of which is of such dimensions as to require a redesigned rear fuselage, fitted with twin tailwheels which touch the runway on take-off and landing. There has been no change in primary armament, but the J 35B incorporates the new Saab S.7 collision-course gunsight and fire-control, and is designed for integration with the STRIL.60 air-defence control system,



Prepared by the manufacturer, these drawings illustrate some of the principal features of the Saab-32 Lansen and Saab-35 Draken (top). Security regulations preclude the addition of most of the Draken systems, but the structure can be seen to be remarkably conventional



Saab-32 Lansen. Span, 42ft 7½in; length 49ft 2in; height, 16ft 5in; wing area, 402.5 sq ft; sweep at 0.25 chord, 35°.

A 32A attack aircraft. One Svenska Flygmotor RM.5 (7,920lb dry, 9,950lb with reheat). Equipped operating weight, about 15,000lb; loaded weight, clean, approximately 22,000lb; max weight, 26,000lb; max speed, over 700 m.p.h. at sea level (M0.92); max Mach number in dive, over 1.1; service ceiling, over 49,000ft; landing speed, 125 m.p.h.

J 32B all-weather and night fighter. One Svenska Flygmotor RM.6B (11,000lb dry, approximately 15,000lb with reheat). Level speed is approximately sonic, and rate of climb very greatly increased.

S 32C reconnaissance aircraft. Data generally as for A 32A, except that operation is rare at weights over 22,000lb; the nose is completely rearranged internally, and maximum range with external tanks is 2,000 miles.

Saab-35 Draken. Span, 30ft 10in; length, see below; height, not stated; wing area, 538.2 sq ft; sweep at 0.25 chord, 80° inboard and 57° outboard.

J 35A all-weather fighter. One Svenska Flygmotor RM.6B (11,000lb dry, approximately 15,000lb with reheat). Length, inclusive of nose probe, 52ft 4in; gross weight, 17,600 to 19,800lb depending on armament load; max Mach number, 1.8 (equivalent to about 1,200 m.p.h. at height); initial rate of climb, approximately 40,000ft/min; landing speed, 130 m.p.h.; min landing run, 1,970ft.

J 35B all-weather fighter. One Svenska Flygmotor licence-built RB.146 with SFA afterburner (13,230lb dry, 17,420lb with reheat). Length, about 54ft; gross weight, clean, 17,900lb; max weight, 20,150lb; max Mach number, 2.05 (equivalent to about 1,400 m.p.h. at height); initial rate of climb, approximately 50,000ft/min; take-off run, clean, 1,300 to 1,900ft depending on conditions.

J 35C trainer. Data generally as for J 35A.

SAAB . . .

A J 35A of the Royal Swedish Air Force is here parked on Saab's airfield at Linköping behind a selection of the stores which it can carry. Among the latter are Rb 324 Sidewinders, rockets of 13.5cm calibre, spin-stabilized weapons of 7.5cm calibre, various bombs up to a weight of 500kg (1,100lb), multi-rocket pods, 30mm guns and an assortment of tanks

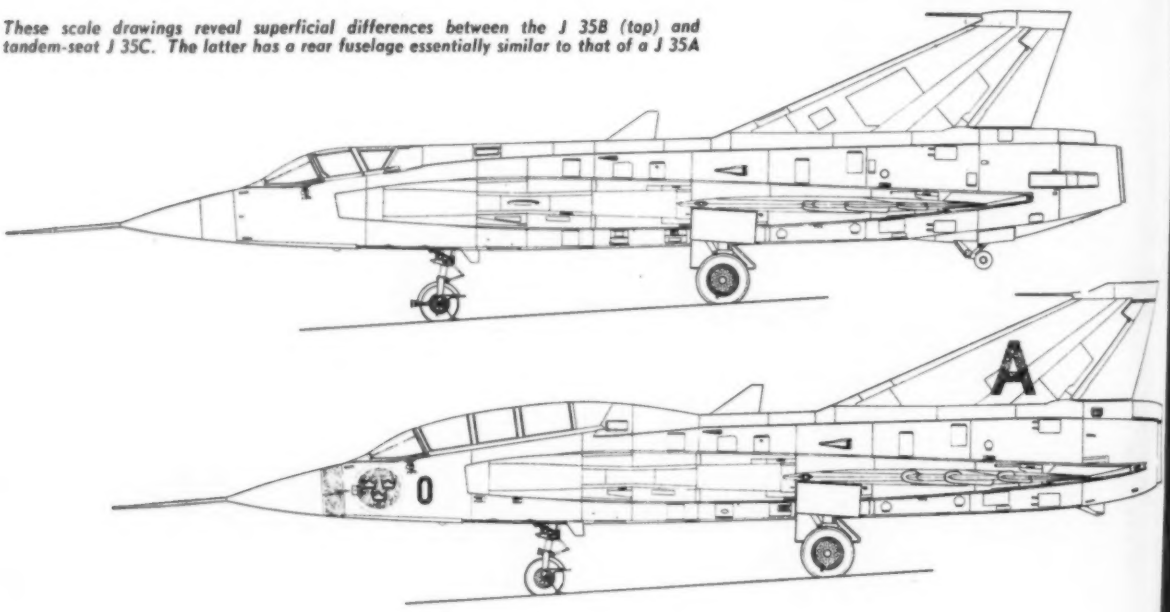
major electronics for which are produced by Marconi. The first J 35B flew late in 1959, and exceeded M2 on January 14 of this year. Deliveries will start during 1961, and will continue for five years. A proportion will be of the S 35B reconnaissance version, carrying a variety of camera pods under the fuselage.

It has long been apparent that the Draken's exceptional qualities make it an attractive export proposition, and Saab have prepared a special version less rigidly matched to the Swedish air-defence environment. Essentially similar to the J 35B, the export Draken is fitted with Ferranti Airpass II radar fire-control, making it a very effective platform for missions against all kinds of air or surface target. There are two separate communications radios, a high-speed data link and two navigation systems (one electronic and the other the ABR dead-reckoning equipment). When the Airpass II is operating in the "ground mapping" mode a map picture is presented on the pilot's radar screen together with information from the ABR system. Instrumentation, largely of Swedish origin, is said to follow "the most modern practice." From the pilot's viewpoint, the new Draken is markedly superior to the J 35A, two of the most appreciated factors being the revised canopy (which gives improved visibility during the approach, requested by certain possible customers) and the fact that the tailwheels allow a pilot to keep the control column hard back during a landing to obtain maximum aircraft drag.

Saab have yet to win an export order with the Draken, but this is not for want of trying. As noted in our December 16 issue, the J 35H, a variant produced for Switzerland, last month thunderously showed off its capabilities among the Alpine valleys in an attempt to win a substantial order from the Swiss Air Force. Its rival on this occasion was the Dassault Mirage IIIC, and it must be recorded that as these words are written the Royal Australian Air Force have chosen to buy the Mirage after what must be the most protracted military-aircraft evaluation on record.

As noted on this page, and reported on December 16, the Saab-35H "Swiss Draken" was last month demonstrated before the Swiss Air Force. The aircraft is here pictured landing at Emmen (Lucerne)

These scale drawings reveal superficial differences between the J 35B (top) and tandem-seat J 35C. The latter has a rear fuselage essentially similar to that of a J 35A



Straight and Level

THE other evening one of my colleagues listened to Mr Stephen Wheatcroft delivering to the Royal Aeronautical Society his paper "Ten Economic Lessons from Short-haul Airline Operations." It is summarized in this issue. About half way through Mr Wheatcroft talked about the problem of how to decide when competition is justified in air transport. "It will," he said, "be essential for our new Air Transport Licensing Board to form a judgment on this question to guide them in their consideration of the applications which will soon be coming before them."

Sitting next to my colleague was a man from Vickers who passed him the following scribbled note:—*"Yes, but first it has to be explained to the Air Transport Licensing Board that there IS a problem. Thinks: how many members of the Board are here tonight?"*

According to the visitors' book in the lobby of the new RAeS lecture theatre, not one.

When the lecture was over, the chairman, Mr Peter Masefield, said among other things in an address of appreciation: "I can't help feeling that this lecture should be required reading for the members of the new Board."

Thinks: Yes, but first it has to be explained to members of the Air Transport Licensing Board, only one of whom has any experience of aviation, that there IS such a lecture.

● At a time when some of the less well established independent air charter companies are falling by the wayside—Orion Airways and Continental Air Transport are examples in recent weeks—it came as some surprise to see an advertisement in Lloyds List the other day which read:—

"WANTED, AIR CHARTER COMPANY. Capable handling 8,000 Passengers 1961 increasing to a potential 20,000 1962 . . . Envisaged fare £23 for 2,400 miles return flight on package deal holiday. Also needed, DE HAVILLAND Heron Aircraft second-hand for conversion flying boardroom . . . Principals reply to Arthur C. Jones, 38 Kings Avenue, Woodford, Essex."

I am sure that many people will be interested in Mr Jones's plans, especially at a time when nobody seems to know how the new licensing laws are going to affect the future. Perhaps his secret is diversification, because he also wants "25 CARIBBEAN-TYPE 'BIG GAME' FISHING BOATS new-buildings, Steel or Fibreglass, 6-seater."

It's all right for the people inside that DC-7, all snug and warm and crunching barley sugar. Who'd be a photographer on a day like this, hanging about at New York to get a special-effect shot for Straight and Level? Don't suppose Bacon'll use it when it comes out anyway

● A press release from Potez informs me: "Au cours d'une campagne de vieillissement d'un Zéphyr CM.175 . . . les pilotes de l'escadrille 59.S embarqués à bord du porte-avions *Arromanches* ont effectué avec cet appareil, en une période de 24 hr, 92 appontages et 93 catapultages sans avarie ni incidents . . ."

The pilot of the 93rd catapultage does not seem to have made his appontage. I do hope he hasn't joined le pauvre Jean Pierre who went missing from this page a few weeks ago.

● "An airplane's soul, which he can never see or touch, is something that a pilot senses: an eagerness to fly, a little bit of performance that according to the charts should not be there, but is; a spirit behind the bullet-holed mass of torn metal with three propellers feathered, touching down on an English airfield.

"Not the metal, but the soul of an airplane is what a pilot wants to fly and the reason he paints the name on her cowling. And with that soul airplanes have that immortality which you can feel when you walk on to any airport."—From an article in *Air Facts*.

● "Copenhagen, Reuter: An investigation has been ordered into the near collision of two airliners over Kastrup here yesterday. The aircraft, an SAS Convair Metropolitan and an Air France Caravelle, were carrying 56 passengers and crew at the time of the incident. The French pilot, who was forced into a vertical climb to avoid a collision, said afterwards: 'We were so close to the SAS aircraft that we could literally smell its exhaust.'"

● "A Pan American Airways DC-3 with 85 passengers flew the 2,960 miles from Boston to Shannon in 4hr 46min yesterday."—*Daily Express*.

● According to a Central Office of Information booklet, BEA's cost level during the past five years has been "reduced from 41.8 pence per capacity ton-mile to 43.1 pence."

Some reduction, eh? But I mustn't be too unkind to the publication concerned, *British Civil Aviation*, which is intended for reference purposes by UK information services overseas. It is an informative and otherwise accurate little work of reference. It is obtainable free from the C. of I. in London.

● From TAA comes this little bit of reported dialogue: "Beechcraft to tower. Beechcraft to tower. Can you hear me? Can you hear me?"

"Tower to Beechcraft. Tower to Beechcraft. Yes, we can hear you, but why are you shouting?"

"I haven't got a radio."

ROGER BACON

How fortunate that a photographer just happened to be in the 707 when these unattainably beautiful girls and handsome men just happened to be grouped together in this natural way. Hundreds of pounds might otherwise have been spent on modelling and photographic fees, etc., and male models are always so ghastly don't you think?

Correspondence

The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns. Names and addresses of writers, not for publication in detail, must in all cases accompany letters.

Difficulties of the Independents

I AM writing about the article in your issue of December 9, page 930, headed "Difficulties of the 'Non-BIATAs.'" The statement in that article about Continental Air Transport attributed to the managing director, Capt Ian McLean, is, I feel, a slight on the engineering department of Continental Air Transport, for the following reasons [Capt McLean was reported to have said that the company had failed because of unserviceable aircraft]:—

During the six-month period April-October 1960 that I was chief engineer, the Vikings (of which we had a maximum of four operational) flew a total of 2,700hr. Viking 'KN did not fly after January, due to its Check 4 and the incorporation of Mod. 1942. These were not completed owing to the lack of spares; for example, powerplants were built up (on two occasions from part-life engines), installed and then removed to fit other aircraft. Furthermore, Check 4s became due on two aircraft towards the end of the summer, and one was carried out during May, June and July. The reason this took so long was once again lack of spares and the fact that once an aircraft became u/s for a major check we used it as a Christmas tree to keep the other aircraft flying.

The maximum number of tradesmen which I was allowed (and this was never constant, due to holidays, sickness, etc.) was six engine fitters and three riggers, plus, for the last month, one electrician. Radio was covered by a licensed engineer plus one, and I had an assistant licensed engineer. With these men we gave 24hr service on the tarmac, completed daily pre-flight and between-flight inspections, and did 31 Check 1s and five Check 2s as well as the rectification of flight defects.

Of the DC-4s, G-APCW came to Continental Air Transport in May, and between then and October flew more than 1,000hr. DC-4 G-APID was due for its Check 4 and went to Hong Kong in May for this work and a major rework, and was returned in August.

When I joined Continental in April they did not have any organization on the engineering side, and not until June was any reasonable accommodation provided for stores, workshops, etc. All work carried out by our engineers was done in the open, often under atrocious conditions of wind, rain and mud, and with inadequate equipment.

Many spares, even to major items such as a propeller and an engine, had to be obtained under the "old pals' act" from other operators. I would like to make it known that had it not been for the friendly assistance of other operators and the absolute maximum assistance and advice of the local ARB surveyor, Mr G. C. Ames, Continental might have come to a grinding halt much earlier.

From the engineering side I can honestly say that we never let the company down in any shape, manner or form. You may think that I am grinding an axe, but I feel you must hear a bit about the other side, even if it is only to do with six fitters and three riggers.

One last word: the aircraft were on every occasion properly maintained and serviceable according to the regulations.

Nicosia Airport, Cyprus — P. S. HARDY

Renfrew Replacement

CONGRATULATIONS on the issue of *Flight* (December 9) dealing with Airports and Equipment, and in particular on M. J. Hardy's excellent article "Can we make our airports pay?"

I am surprised, however, that the recent decision by the Minister of Aviation to substitute Abbotsinch for Renfrew, when the latter is closed in 1963, has not aroused some comment either in Mr Hardy's article or in any recent issue of *Flight*. The fact that some £3m is likely to be spent on developing a new airport which will inevitably be run at a loss surely justifies some exploration into the reasons given for the choice of Abbotsinch being made the alternative to Prestwick.

Only one argument in favour of Abbotsinch has been put forward, and that in the form of an objection to Prestwick. It is said that Prestwick is too far from Glasgow, but surely it is becoming more and more evident that distance should not be measured in miles but by the time of the fastest regular transport. This being accepted, the point in favour of Abbotsinch disappears when it is known that a rail service, similar to that provided between Gatwick and London, can bring Prestwick within 35 minutes of Glasgow city centre. A further reduction in total time can be made if consideration is taken of five minutes' less flying time to Prestwick from points south of Glasgow. Even in the quietest road traffic conditions, Glasgow city centre to Abbotsinch takes some 25 minutes and the nearest railway line is two miles away. It appears therefore that a new civil airport is to be developed on the doubtful strength of a few minutes' travelling time.

Renfrew's closure is necessary because of its incapacity to expand due to the surrounding built-up area and also because of its already somewhat marginal operating conditions brought about by a main runway length of only 5,789ft, obstructed approaches, frequent cross-winds on its main runway and, of course, the all-too-persistent Clyde Valley fog. One would assume, therefore, that Renfrew's replacement would be chosen to remove the above-mentioned shortcomings. The fact is that Abbotsinch is less than two miles from Renfrew and therefore subject to the same weather conditions, including fog. The runway bearing is also similar to Renfrew's main runway so the cross-wind hazard remains. At one end of the Abbotsinch runway there is a built-up area and the other end plunges into a marsh. Runway extension is only possible towards the built-up area and then only to a maximum which brings the total length to under 700ft more than that of the main runway at Renfrew. One is inclined to question the point of transferring operations at all.

It is now interesting to note the possibilities of Prestwick having been chosen as Renfrew's replacement. Examining Prestwick as it will be when current development contracts are completed, we find an airport with runways catering for the largest aircraft and presenting no crosswind problem. Clear approaches, the unrivalled fog-free weather record and a large modern terminal building with an adjacent railway will offer an opportunity to both operators and travellers alike to avail themselves of what could be the most comprehensive and convenient travel centre in the United Kingdom. Prestwick already has six international airlines providing passenger and freight services to all points of the globe, and it is already evident that although in the past transit traffic has contributed the largest percentage of passengers, terminal traffic is quickly expanding and terminal figures have already overtaken transit figures..

It seems therefore that a figure, variously estimated at up to £3m, is to be spent on a new civil airport, offering little betterment, if any, over that which it is designed to replace. The alternative was to spend an estimated maximum of one-tenth of that figure on additions to the new Prestwick terminal building and to provide travellers and operators with a reliable and efficient air terminal. There is also the distinct possibility that at least one airport in Great Britain would be financially self-supporting.

Prestwick, Ayrshire — ROBERT A. WATT

Treasure Hunt

WE are attempting to trace No 57 Sqn silver which may have been displaced in the passage of time. The amount of silver held by the squadron is extremely limited and as the unit has been in service for a total of almost 25 years we feel that more may have existed at one time or another.

The squadron was formed in 1916 and served in France until disbanded in 1919. Reformed in 1931 at Netheravon, it was based at Coningsby, Cottesmore, East Kirby, Feltwell, Lindholme, Hemswell, Waddington and Scampton, at various times, until disbanded at Coningsby in 1957. Currently the squadron is serving at Honington, having been reformed in 1959.

May I, through your publication, appeal to your readers for any information on the whereabouts of No 57 Sqn silver.

A. G. ELTRIDGE, Flt Lt

RAF Honington, Bury St Edmunds, Suffolk

Might it have been Mavis?

I WAS appalled to see in Roger Bacon's column "Straight and Level" references to a conversation between an air correspondent and my colleague "Washers." As you know, "Washers" is one of the best, having graduated from the Fleet Street School for Public Relations Officers early in '59. He wears the lapel badge of a "Senior Bore" and is the most prolific writer of hand-outs in the business.

You will recall his masterpiece on the Speedmaster—which, incidentally, gave Angus Swoon and his colleagues some hint of performance (". . . it can fly faster and more steadily than a Thor . . .")—and his build-up of our chairman, Lord Dribblepuss, when the latter tried (abortively, unhappily) to sell the Scruggs "Hamburger" fighter-bomber to the Germans.

I can only think that in managing to report the conversation between "Washers" and Swoon as accurately as he did, Roger Bacon had our office in Pell Mell "bugged." (Or it may have been Mavis.)

Whether Swoon will be writing to you, I can't say. I hope he does. All I want to make clear—and I hope you will publish this letter—is that Scruggs Aircraft, Government subsidy or no Government subsidy, is anxious to see that Swoon doesn't.

Scruggs Aircraft Ltd, London SW — TRUGLIG RETRAC

Still going strong as a business aircraft is the Beechcraft 18. Here is the 1961 version of the Super G18S, one of eight Beech models being marketed for the new year

Sport and Business

A BUSINESS AIRCRAFT USERS ASSOCIATION is to be formed to represent the interests of business aviation in Britain. At a meeting of about 60 users in London on Thursday, December 15, a steering committee was formed to begin organizing the Association, which is to come into being early in the new year. The BAUA will operate in close liaison with the Aviation Committee of the Royal Aero Club, with the object of providing a strong and unified body to represent the interests of business aircraft users and also to act as an information centre for members and prospective users. Members of the steering committee are Mr K. McAlpine, director of Sir Robert McAlpine and Sons Ltd; Mr M. A. H. Bellhouse, director of the Pressed Steel Co Ltd and of Beagle; Mr Hector Lang of McVitie & Price Ltd; Mr T. A. Vigors, of Vigors Aviation Ltd, who is chairman of the Royal Aero Club's business aviation advisory committee; and Mr Peter Masefield. The last two are acting in an advisory capacity. The honorary secretary is Sqn Ldr R. R. Stephenson, aviation secretary of the Royal Aero Club. Three further business aircraft users might also join the steering committee.

The formation of the Association was proposed at the meeting by Mr Peter Masefield, chairman of the RAeC aviation committee, and was unanimously approved by those present. It was announced that £2,000 had been guaranteed to get the Association going but that £5,000 was the initial target and contributions were invited. Speaking about the purpose of the association, "Tim" Vigors said that the greatest bottle-neck in business flying in this country was the lack of suitable business airfields for London. The Royal Aero Club had already made considerable progress in obtaining Ministerial approval to retain a portion of Croydon Airfield as a business aircraft base. Similar efforts were now being made to obtain the use of Hendon and Northolt and the first steps had been taken to obtain permission for business aircraft to use London Airport. The BAUA was the right body to attempt to obtain this kind of facility.

Guest of honour at a Royal Aero Club house dinner on December 14 was Maj Oliver Stewart, editor of "Aeronautics" (right), seen here with Mr Edward Bowyer, SBAC director and former aviation journalist

Another task was to ensure that, in the allocation of airspace and priorities, business aircraft were considered on an even footing with airliners. More Customs facilities were required because business aircraft now going foreign often had to waste 40 minutes making an additional landing to clear Customs at one of the few fields where these facilities were available. The Association would watch new regulations and ensure that they were not prejudicial to business aircraft and would also try to ensure reasonable insurance terms. The new body should provide a pool of knowledge on aircraft operation and should be able to advise those who considered using aircraft on business. There should also be a flight information centre to advise on facilities available in Britain and abroad. Efforts should be made to have present import restrictions eased.

It is intended that the Association shall be open to all those who use aircraft on business whether they employ professional pilots and fully equipped aircraft or not. The BAUA would probably make contact with the National Business Aircraft Association, and possibly with the AOPA, in the United States. Operating in association with the Royal Aero Club and having a cross-section of the country's industry in its membership, the BAUA should become a powerful organization well able to look after the interests of its members. Its formation is certainly the most important step forward yet taken in this field. As a business aircraft operator of long standing, *Flight* strongly supports the Association.

RETROSPECT

From "Flight" of December 31, 1910

Brooklands Aerodrome: On Thursday, 22nd inst., Mr. England brought out the new E.N.V. Weiss, and soon attained a height of some 40 ft., flying the length of the ground. This novel machine does not appear to turn readily, as the pilot found. It heeled over to such an angle that it culminated in a smash, Mr. England claiming acquaintance with the sewage farm, the machine losing its chassis and damaging its propeller. The aviator looked unhappy, but was fortunately unhurt. The Bristol biplane, piloted by a pupil, ran into a mound, also damaging its chassis . . .

FIRST AERO COMMANDER to be sold in Britain was handed over to Mr Geoffrey Woods, chairman of Woods of Colchester Ltd, at Wormingford Airfield on December 16. The aircraft is a Commander 500B with the registration G-ARGW, and was flown over from the Aero Commander factory in Bethany, Oklahoma, by Woods company pilot Peter Wellby. United Kingdom agents for Aero Commander Inc (formerly Aero Design and Engineering Co) are Field Aircraft Services Ltd, who hope to import a second Commander for use as a demonstrator next month.

HERTS AND ESSEX AERO CLUB held a breakfast patrol at Stapleford on Sunday, December 11, at which three of the 29 visiting aircraft succeeded in arriving unobserved and winning free breakfasts for their occupants. Seventeen defending aircraft were involved. Among the prizewinners was Colin Chapman, designer and maker of the Lotus Grand Prix racing car.

THE SALE of new German light aircraft, and second-hand American aircraft through the agency of the Norman Larson Co, will be handled in this country by the newly formed Flair-Aviation Sales Company, Tower House, College Road, Bromley, Kent (Ravensbourne 7277).

High-speed touring plus aerobatics is the formula of the Aeromere Falco F-8L two-seater emphasized by the British agent, Mr J. L. Shaw, here seen in the cockpit. UK price is £4,700

SUPERSONIC - TRANSPORT IMPLICATIONS

More About the RAeS Symposium

AN initial report was published in last week's issue on the Royal Aeronautical Society's symposium on supersonic transport aircraft, held in the new RAeS lecture theatre on December 8. This further account covers the remaining papers delivered and the subsequent discussions.

PODS, or buried engines? This hoary old question, which was so hotly debated when contemporary jet airliners were lines on a drawing-board, cropped up in a new context at the Royal Aeronautical Society's symposium on supersonic transport aircraft.

The chief technician of the Hawker Siddeley advanced projects group, Mr P. L. Sutcliffe, put forward a strong case for podded engines on supersonic airliners when he addressed the 400 engineers, pilots and planners attending. He said that podded engines can now be far more closely cowled, with the grouping of accessories in the pylon, than was once thought possible. Thus low frontal areas could be achieved and very similar wave drag could be obtained for the podded engine and the two dimensional, semi-buried installation. There was little to choose in weight between the two types of installation.

It was in removing and dispersing the boundary layer that the podded engine offered its advantages. A semi-buried installation would probably have a considerable boundary layer ahead of its intake ram, whereas with the podded engine there would be a boundary layer present only on the intake centre-body. "Lots of effort must be placed on the podded engine," said Mr Sutcliffe. "It's a runner now, though it did not at one time appear to be."

The question has never failed to provoke controversy and it did not fail to do so at this symposium. Dr Seddon, of the RAE, took issue with Mr Sutcliffe, saying: "Our future lies in more sophisticated integration of shapes. Burying the engines is only the first stage in solving the integration problem." Dr Seddon called for more positive thinking on treating the boundary layer.

A speaker from the National Gas Turbine Establishment supported the podded engine by saying that the complete powerplant would have to be exhaustively tested in development and a podded installation could be tested with very little extension of existing facilities. He predicted that the development of two or more engines sharing the same variable intake would be a very difficult task.

Mr H. Pearson, of Rolls-Royce (whose paper was reported last week) implied support for the buried engine by commenting that one could not make such a practical and efficient circular intake as a flat one. The rear-mounted engine was very much in vogue and was better because of the noise fatigue problem—though he thought those might be "famous last words."

Mr Wolfe, of the RAE, had brought up the question of fatigue being caused by high noise levels at take-off and during the climb. Boundary layer noise came into this; during tests at RAE with a Fairey Delta they had found boundary layer noise as high as 140PNdb, a level just capable of inducing fatigue.

Another speaker from Hawker Siddeley's advanced projects group, Mr Morris, supported Mr Sutcliffe and left no doubt in his listeners' minds that Hawker Siddeley's eggs are packed in podded baskets. He said that the failure of one variable intake in an integrated installation would affect all the engines: for one failure, there might be a triple failure. The only possible justification of the integrated installation, in his view, was lessened drag.

Sonic-boom problem

The first gloomy prognostications about sonic booms, the one problem which dominated the whole symposium, were aired by Mr Sutcliffe in his paper. Nobody had yet experienced regular sonic bangs, such as would be generated by scheduled supersonic aircraft, and it was difficult to forecast their effects. The weight and altitude of the aircraft were the two factors which determined shock-wave intensity at ground level, measured in lb/sq ft. It appeared that all but the lightest aircraft flying supersonically above 60,000ft would produce a shock wave at the ground well in excess of 1lb/sq ft—and that allowed for a reflectability factor of two, measuring the shock as a human being would experience it in his ears when standing on level ground.

An M2 aircraft flying at 60,000ft would leave behind it a "continuous boom region" about 30 miles wide for all but the first and last 80 miles of its flight. This would be a serious public nuisance; but the speaker displayed a "press on" spirit, feeling that the design of supersonic aircraft should continue while the answer to the problem and the tolerable levels were sought.

Mr Morris was very pessimistic on this question. He thought that any supersonic transport of more than 200,000lb was going to generate shock-waves of objectionable intensity. Millions of people would be affected, say, by a coast-to-coast supersonic flight across the USA. He thought that both the British and United States Governments would prohibit supersonic airline flying over populated areas. "If we prohibit it, can we expect Egypt, Iraq and all the others not to do likewise?" he asked. He then turned to the economic effects of such a prohibition. A 35 per cent increase in direct operating costs would result on the London - Los Angeles route from the need to fly subsonically over parts of the routes. Fifty per cent would be added to costs between London and Johannesburg, 40 per cent between London and Sydney and 70 per cent between London and Tokyo.

One of the three airline speakers, Mr C. H. Jackson, BOAC's assistant chief engineer, displayed the airline man's proper caution in not wanting the supersonic transport to be developed until the nature of the shock-wave problem was known and its solution found. His talk on operations and economics was tinged with witty cynicism.

"Operators have been told that supersonics are a new and faster way of going places," he began. "We are told that their effects on human affairs 'are not exactly known, but are bound to be beneficial. The technical challenge should be exciting and we must remember it involves national prestige. Let's find the funds and get on with the job.'

"The same kind of argument probably motivated Columbus," Mr Jackson said. The challenge of the supersonic transport was an economic one and designers must not forget this. Unlike any other industry, the airline industry's product had grown progressively cheaper. Every major advance had resulted in lower seat/mile costs and therefore lower fares. "This economic progress is seen in current economy-class fares. These are down 30 per cent when all retail costs have increased." For this reason, airlines eyed supersonic transports with suspicion. The top ten per cent of total traffic (Top People?) would be insufficient to support large-scale supersonic airliner production, so costs must not be substantially increased. If subsonic costs could be considerably decreased from present levels, the supersonic transport might then bear the differentials.

Supersonics and ATC

The economic advantages claimed for M2 or M3 transports might disappear if kinetic heating demanded special and expensive fuels or additives, Mr Jackson considered. With regard to gaining the best utilization, he did not think that equipment pooling between airlines would help much: "There is a limit to how much one can lower the frequency of service, or restrict the passenger's choice of carrier, in return for shorter journey times." He was worried about the air traffic problem. Would a system failure causing a delay of 10min lose the aircraft its departure "slot" in a highly geared ATC system? (Capt Kane, of BOAC, later commented that he saw "no hope whatsoever" that ATC authorities would accept supersonic aircraft by 1970.)

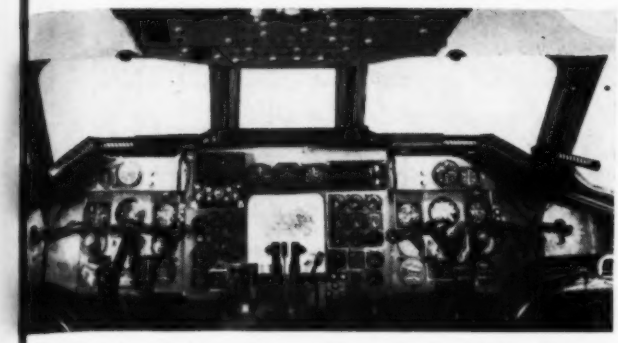
Then the meeting was brought back to sonic booms again. If booms, or rather the avoidance of them, dictated subsonic over-land flying or lengthy coastal diversions, particularly around India, the Polar route to Australia could be used, flying south over the Pacific. This would increase the route distance and lose valuable sector business. "Sector business is a valuable part of BOAC's whole business," Mr Jackson said. "We haven't the operational answers; we haven't the information to provide the answers. In this we are no worse off than any other operators—we all have to wait a year or so for more information from aircraft designers," he concluded.

The first questioner foresaw that the avoidance of booms over populated areas could lead to an unbalanced transport system by 1970. In terms of elapsed time, New York might be nearer than Rome and Australia nearer than Cairo.

It was a safe bet that with members of Handley Page's engineering staff in the theatre, the audience would hear of the benefits of boundary layer control. Mr C. Lee was quickly on his feet to indicate that the company had studied BLC for both subsonic and supersonic applications. Mr Jackson might have underestimated the competition which supersonic aircraft would have to face from cheaper subsonic types. BLC could bring down subsonic operating costs to only 6d/ton-mile from 1s/ton-mile. The best hoped for from a "conventional" M2 aeroplane was 15d/ton-mile.

"What is the answer?" asked Mr Lee. "Why, a more efficient M2 aircraft, one with BLC!" Supersonic operating costs would then drop to perhaps, 11d/ton-mile. A more exotic solution, of course, was variable geometry. "A slewed wing sounds nice," he said. "It gives the sense of intoxication appropriate to this kind of thing."

British European Airways were represented at the symposium by their flight technical superintendent, Capt F. Ormonroyd, who thought that operating techniques of supersonic aircraft might



"The close packing of instruments, as in the Trident allows any departure from the norm to be seen at a glance"—Capt F. Ormonroyd (Sperry, Smiths and Kelvin Hughes collaborated in the instrumentation)

be indistinguishable from now-evolving short-haul techniques. "It is well known that the rate of error in task performance increases rapidly after a certain complexity is reached," he said, "or after a certain rate of operation, ambient noise level or temperature is attained." BEA's view was that as much assistance should be provided for the pilot as possible. He should be the brain behind the operation, rather than a servo link as in the past. The BEA conception of an aircraft captain's role was one of managership.

The corporation was now completely wedded to the idea of small two-inch dashboard instruments. The close packing of instruments, as in the Trident, allowed any departure from the norm to be seen at a glance. Readability was not affected by abandoning the standard 3½in instruments, for very close readings, say to 1° with 20° to a peripheral centimetre, required a much more sophisticated instrument, with servos, anyway. He thought the para-visual director, to be fitted in the Trident, was "very impelling, and a very powerful tool." It could even be used for controlling the aircraft when rolling after touch-down. Capt Ormonroyd spoke at some length on automatics—the more the better, he thought. He wanted a small tiller control at the captain's hand, as they had in the Vulcan.

In the discussion which followed his talk, there was revealed considerable divergence between the BEA view, as expressed by Capt Ormonroyd, and the BOAC view, expounded by some of the corporation's captains from the floor. The irrepressible Capt Kane was rather sceptical about these automatic systems and asked for the speaker's views on the approach and landing of supersonic airliners. "I'm an automatics man myself," said Capt Ormonroyd. This phase must be tackled with automatics in mind, and should be made completely automatic. "Let's have four autopilots if necessary," he added.

Automatics were the concern of another paper, read by Mr Shaw, deputy chief project and development engineer of BEA, for its author, Mr R. C. Morgan, his chief. The complexity of systems in contemporary subsonic aircraft must not be underrated, and the potential rate of systems unserviceability in supersonic aircraft was not more than 30 per cent higher. Systems multiplication would be the main tool by which the new requirements would be met, but completely new standards of systems capability would have to be achieved.

One example was in air conditioning, where high wing temperatures would impose far greater reliability standards than have been needed so far. They would operate over much greater temperature ranges—from 15°C at take-off, down to −15°C on the climb, and up again to 250°/300°C in the cruising phase. To ensure systems reliability, testing away from main bases should be avoided and systems made to indicate their failures. The development of flight recorders would be invaluable in this respect. There was nothing to be gained by fitting complex automatic check-out equipment in civil aircraft, for the mere performance of its tasks by a busy aircraft was the best indication of its serviceability.

This point aroused interest in the audience. Sir George Gardner, the chairman at the session, asked for clarification of the speaker's views on automatic check-out equipment. The answer he received was that it would be undesirable because the more one switched electrical equipment on and off, the more likely it was to fail the next time. Mr Symons, of Vickers-Armstrongs, commented that the same applied to manual checking, but the speaker felt that manual checking really consisted of switching on, *for operation*, and seeing that the system functioned. He felt that systems for supersonic aircraft would not be beyond present-day design and maintenance capability. They would, however, require far greater spares holdings than contemporary systems, for which due economic allowances must be made.

Vickers-Armstrongs' chief structural engineer, Mr David James, spoke earlier of kinetic heating—the most critical structural aspect of supersonics. He warned that the significance of kinetic heating must not be exaggerated if excess structure weight was to be avoided. Kinetic heating introduced three new factors which had not so far been of great concern. They were the effects of high temperature on the mechanical properties of structural materials, the development of self-equilibrating load systems due to temperature gradients through structures, and the effects of creep under sustained loads on the permanent deformation of structures.

The present ultimate strength requirement of 1.5 times the proof load covered uncertainties in the estimation of loads, stress distribution and failing stress. Supersonics added the estimation of temperature to this list. Only if the errors of temperature estimation were of greater significance than past experience showed should this safety factor be increased.

Mr James showed a graph depicting the percentage error in the strength estimation per degree error in temperature estimation for three well-known alloys. The greatest percentage error, 2 per cent at 130°C, occurred with aluminium-zinc alloy widely used in structures. For the other two alloys cited, much lower errors were recorded, and these at higher temperatures. As a supersonic airliner would almost certainly fly with a temperature placard limita-

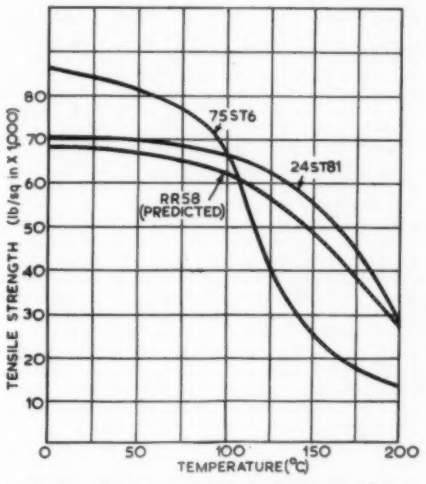


Fig 1. Tensile strength v temperature (10,000 hours' exposure); from the paper by Mr David James of Vickers-Armstrongs (Aircraft) Ltd

tion, he suggested that there was no case for the inclusion of a special safety factor to cover errors of temperature estimation, provided that the right types of alloys were chosen.

A temperature gradient in the structure would induce a self-equilibrating stress system, necessary to achieve compatibility of strain. Thermal stresses were induced in achieving this compatibility, and as the modulus of elasticity decreased, they decreased. As the ultimate strength of the material was approached, they became insignificant.

Elastic instability or metallurgical failure could cause the ultimate failure of a component. Elastic instability nearly always occurred at stress levels at which the modulus of elasticity was equal to Young's modulus and in these cases the presence of a temperature gradient would substantially affect the external load a component could carry. The speaker suggested, therefore, that a safety factor should be applied to the thermal strain and mentioned the factor 1.5. Fatigue implications were likely to be far more critical than the static strength implications of thermal stresses. The most critical areas were likely to be hidden well within the structure, making early detection difficult.

Creep was a new problem for structural designers and engine designers' experience of it would be limited to short-term creep. Mr James did not think it would be significant if the steady stress level in the supersonic phase was kept below some critical value determined by the temperature and the material used. From extrapolated data on 24S T86 alloy exposed for 30,000hr at 150°C it appeared that if a reasonable margin of safety against creep rupture was to be obtained, a permanent creep deformation of 0.1-0.2 per cent was all that could be allowed.

Creep deformation would develop at different rates throughout the structure, owing to different stresses and temperatures. The result would be the progressive build-up of a self-equilibrating

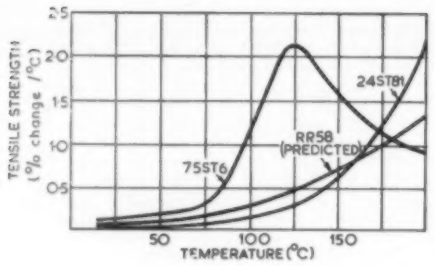


Fig 2 (left). Tensile strength variation at high temperature (10,000 hours' exposure)

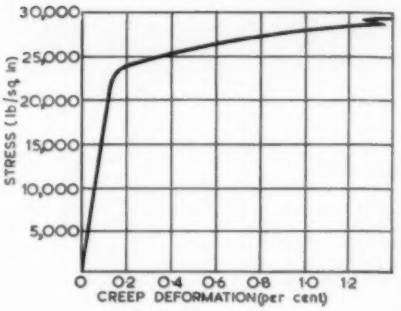


Fig 3 (right). Stress-creep deformation. Material, 24S T86; exposure, 30,000hr at 150°C (extrapolated)

SUPERSONIC-TRANSPORT IMPLICATIONS . . .

stress system which might be significant. Buckling characteristics of skin panels might change and the pattern of fatigue stresses be altered by a continuous change in local mean stress levels. These aspects of creep are the ones about which least is known.

Among questions put to Mr James was one asking why he had extrapolated data to 30,000hr in his creep calculations. "There seems to be a safety factor of two in this and it may prejudice the final answer," said the questioner. The speaker replied that 30,000hr "came out of the hat"; but airlines often bought aircraft for an operating life of 10,000hr and then expected to work them for 30,000. To another questioner he said that he thought calculations of stresses for the supersonic regime would be more accurate than those that would be made for the high subsonic speed range. On flying an aircraft to a temperature placard limitation a BOAC captain foresaw difficulty in slowing down if there was a sudden temperature rise when flying near the placard speed; but the speaker thought that even at the placard limitation there would be an adequate safety margin.

Dr N. J. L. Megson, director of materials research and development at the MoA, agreed that 30,000hr was a reasonable life to aim for when developing materials. He spoke on materials metallic and non-metallic and said that a very big programme of testing material at high temperatures must be undertaken. All such tests to date had been for comparatively short periods and comparatively low temperatures. One could not extrapolate with accuracy the figures for materials performance at room temperatures, but one could make intelligent guesses. Aluminium alloys would be suitable for structures at speeds of up to M2.2 (approximately 130°C), but steel and titanium would have to be used for M2.7 (approximately 200C°).

The situation was far less clear concerning non-metallic materials, for tyres, seals, transparencies and radomes. Most non-metallic materials used so far have been organic (carbon) ones, subject to softening and decomposition at high temperatures. Improvements made in their performance so far had only been marginal. Inorganic and semi-organic materials must be investigated, and this would involve research into a virtually new field of chemistry.

Reverting to and enlarging on metallic materials, Dr Megson said that of the very large range of structural aluminium alloys available, three were very commonly used. Of these, the one with the highest strength at room temperatures, DTD-687, became the worst after a long soak in high temperatures. This underlined the dangers in extrapolating known data. Three new bearing alloys developed for use in engines were worth study as structural materials. One was X-2020 and was unusual in containing lithium. Its density was 2 per cent lower and its Young's modulus 6 per cent higher than those of normal copper bearing alloys. Another, Firth-Vickers 520 steel alloy, was being examined at the moment. This was now available in sheets up to 40in wide and was expected to be available in sheets of acceptable flatness.

Despite the availability of titanium alloys of specific strengths greater than steel at temperatures of up to 300°C, there were a number of disadvantages applying to titanium at the present time. These alloys had lower specific stiffness than steel alloys and there was a smaller range of material sizes. Manufacturing techniques still required development. Its greatest disadvantage was its cost—some twenty times that of 520 steel.

Turning to transparencies, Dr Megson said that normal Perspex materials softened at 90° to 100°C, but one derivation, Avialite, might be acceptable for temperatures up to 130°C and was being

(*Concluded on page 1031*)

THE INDUSTRY

Atom in Camera

ON December 14, Sir Roger Makins, chairman of the UK Atomic Energy Authority, opened an exhibition of photographs at Ilford House, Oxford Street, London W1, under the title *Atom in Camera*.

Among the many prints showing the varied uses of atomic energy for peaceful purposes was one of a research balloon ready to leave the flight-deck of USS *Valley Forge* in the Caribbean. Helium-filled, the plastic balloon had a capacity of 10m cu ft and reached a height of more than 20 miles before being brought down under radio control and recovered from the Atlantic.

Carried by the balloon were two stacks of Ilford nuclear emulsion, each weighing 6 cwt and designed to make visible the tracks of single-charged atomic particles. A much-enlarged record of a track left in the emulsion was also shown.

Other stacks of nuclear emulsion have been flown in rockets and in satellites with recoverable nose capsules. A research programme has been initiated in the US to develop an emulsion-recovery vehicle, NERV, the main purpose of which is to make measurements of the Van Allen radiation belts. NERV will be sent to a height of 10,000 miles.

A nuclear emulsion differs from an ordinary photographic film in that the concentration of silver halide is much greater and is coated some 50 times thicker. This produces sheets 0.6mm thick which are used without glass or film support. Large numbers of sheets are bound tightly together to form a solid "stack." The biggest stacks so far made are those taken up from *Valley Forge*. Each comprised 500 sheets 24in by 18in.

It was largely for his research work in this field of sensitized photographic emulsion that Mr Cecil Waller, chief emulsion chemist at Ilfords, was elected a Fellow of University College, London, and also awarded the Progress Medal of the Royal Photographic Society.

The exhibition, admission to which is free, will remain open until mid-February.

IN BRIEF

Spurling Motor Bodies Ltd state that there is a full order-book for their "Stairways to the Airways" passenger steps, and for aircraft seating made by their subsidiary L. A. Rumbold & Co Ltd.

Mr A. M. Hudson Davis, OBE, MA, FIWM, managing director of Fibreglass Ltd, was recently elected chairman of the Institution of Works Managers for 1960-61, the thirtieth year of its establishment.

Aviation Developments Ltd, manufacturers of Avdel fasteners and other products, are building new office and factory premises at Welwyn Garden City, Herts, scheduled to be ready for occupation in April next year.

Mr Sydney Oxon, a member of the sales organization of the Goodyear Tyre & Rubber Co (Gt Britain) Ltd, retires tomorrow after serving the firm in various important capacities for more than 44 years. He was recently presented with a gold watch by Mr M. S. Meyer, Goodyear managing director, and colleagues' subscriptions have also made possible the gift of two wing armchairs.

The Firth Cleveland Group has formed a new company, Firth Cleveland Steel Ltd, with registered offices at Wentworth Street, Sheffield, Yorks. It will operate from Holmes Mill, Rotherham. The chairman is Mr C. W. Hayward, chairman of Firth Cleveland Ltd, and the managing director Mr John Tonking. The new company brings together J. J. Habershon & Sons Ltd, the Tenuous Steel Co Ltd and Firth Cleveland Steel Strip Ltd, operating to provide a wide range of specialist steel strip.

To achieve closer liaison between their technical, production and sales departments, Chloride Batteries Ltd are transferring the major portion of their sales headquarters from London to the company's head office and principal manufacturing centre, Exide Works, Clifton Junction, near Manchester, from January 2. A London sales office for automotive equipment, Government and dry battery business will be maintained at the present address, Grosvenor Gardens House, Grosvenor Gardens, SW1, until January 30, when it will be transferred to 137 Victoria Street, SW1 (VICtoria 2299).

This was the scene at Hatfield on December 15 when, on the date announced nine months ago, de Havilland delivered to Sheikh Najib Alamuddin the first of MEA's four Comet 4Cs. See note below
"Flight" photograph

AIR COMMERCE

THE SHEIKH GETS HIS FIRST COMET

WHEN Sheikh Najib Alamuddin, chairman and managing director of MEA, ordered four Comet 4Cs last March it was stated that delivery of the first aircraft would be on December 15, 1960. This was the first time that any British aircraft firm had ever publicly stated the actual day on which an aircraft was to be delivered. On December 15, as promised, the Sheikh was at Hatfield to take delivery of his first aircraft (see photograph, p. 1003).

On December 19 the aircraft departed for Beirut to prepare for the first actual MEA-operated Comet service, which is due to be inaugurated on January 6. Since November 1 MEA have been chartering two Comet services a week from BOAC on the routes from Beirut to London and Dhahran.

Delivery of the Sheikh's first Comet is a happy ending to the strained relations between the airline and this country evident only a year ago. The trouble began when, in September 1959, the Sheikh took strong exception to suggestions that MEA was "one big sieve through which public money has been poured" [Mr Frank Beswick, MP]; and "We can't go on with the drastic losses in MEA. Matters must either be wound up or some different arrangement come to. I regard the situation as being extremely grave." [Mr Harold Watkinson, Minister of Transport and Civil Aviation.] Previously Sir George Cribbett, former chairman of BOAC associated companies, had said: "We feel we have sunk so much money in MEA, to wit £6m, that it has a very important role to play in the Middle East because these Arab countries are tending more and more to make it difficult for us as a corporation to acquire traffic rights."

Through his public relations consultants in this country, the Sheikh strongly countered these remarks, pointing out the value of BOAC's investment in MEA, particularly as regards traffic rights and feeder and interline traffic, worth together nearly £2m a year to BOAC. MEA pointed out that it had spent more than £5½m on British aircraft since 1955, and pointed out that the year under review, 1958, had been poor (a loss of more than £1.7 million) mainly because of the Lebanese revolution.

BOAC has invested more money in MEA than in any other subsidiary. As well as owning 49 per cent of MEA's shares, BOAC has advanced some £5m for equipment and funding purposes, as well as having spent about £1½m on MASCO, the engineering concern disbanded last August and integrated into MEA because the Sheikh wanted Comet maintenance under his airline's direct control.

At any rate, having weighed his natural wish for independence with the undoubted advantages of being a BOAC associate, the Sheikh decided that the Comet was the aircraft he wanted. However, last March—after prolonged discussions—he found it necessary to issue an ultimatum to the effect that unless H.M. Treasury approval for the order was forthcoming by March 15 he would have to "go elsewhere" for Caravelles or Convair 600s. Treasury approval was almost immediately forthcoming, and BOAC guaranteed the financing arrangements in what was described by the Chancellor of the Exchequer as "a highly complicated and intricate case." According to MEA, BOAC's guarantee covers only MEA's instalments, and not the down payment, total purchase price being about £5½m. The reason why BEA had to guarantee the MEA order at all was because this had been asked for by de Havilland.

All MEA's Comet 4Cs will have been delivered and put into service by March 31, when BOAC Comet 4 charter expires.

VANGUARD STARTS WORK

FARE-PAYING passengers travelled by BEA Vanguard for the first time on December 17 when G-APEE (Capt A. S. Johnson, Vanguard flight manager, Capt W. J. Johnson and Capt H. C. Bailey) helped out with the pre-Christmas air rush on the London - Paris route. Other "holiday help" flights are being made by Vanguards on the routes from London to Glasgow, Geneva, Zurich, Dusseldorf and Barcelona.

Regular Vanguard services will begin on March 1 on the London - Paris route. On April 1 Vanguards will serve Madrid and the domestic trunk route to Glasgow; on June 1 they will serve Malta via Naples and Rome, on July 1 Belfast, and on August 1 Milan and Edinburgh. Seating is 96T and 18F.

BEA's second V.951, 'EF, was delivered on December 13, and the third was due on December 24. No 4 is due next week, No 5 during the last week of January and No 6 during the last week of February. Then will follow, at the rate of one per month between May and August, four of BEA's 14 V.953s. The remaining ten will follow at the rate of two per month between September 1961 and January 1962.

New York Airways are now operating a Boeing Vertol 107 on proving flights from the Port Authority's new Wall Street heliport. A fleet of ten of these twin-T58 25-seaters is due to enter service next spring

AIR COMMERCE . . .

THE NEW YORK COLLISION

AN intensive investigation is now under way into the mid-air collision over New York on December 16, at about 1635 GMT (1035 local time) between a United Air Lines DC-8 bound from Chicago to Idlewild and a TWA Super Constellation bound from Dayton, Ohio, for La Guardia.

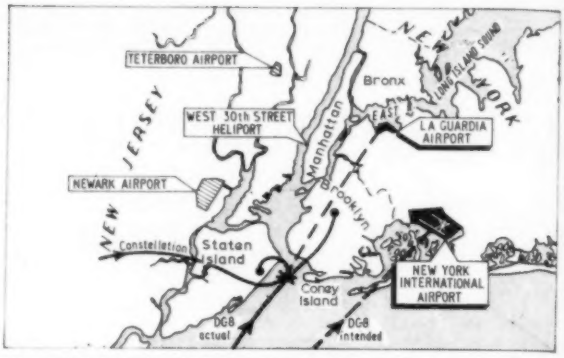
The final death-roll was over 140. All 126 occupants of both aircraft, and twelve people in the Prospect district of Brooklyn, where the DC-8 came down, were soon known to have been killed —77 passengers and seven crew on board the United DC-8, and 37 passengers and five crew on board the TWA Super Constellation. It was the worst disaster in the history of civil aviation; the previous worst was the collision between two aircraft of the same airlines over the Grand Canyon in June 1956, when 128 people died.

According to a variety of reports, some of them originating from members of the investigating team and others from traffic control personnel at Idlewild, the Super Constellation approaching New York from Ohio followed Victor 6 airway south-eastwards and flew to Linden, a few miles south of Newark. It passed Linden at 5,500ft, was cleared to Coney Island reporting point and was then to turn left, north-eastwards, on to the ILS for La Guardia. The DC-8, from Chicago, passed Willow Grove VOR just north of Philadelphia on a southerly circling approach into the New York area. At Columbus reporting point it turned north along Victor 123 to Preston reporting point, which is on the mainland ten or 15 miles south of Staten Island. There it should have turned right over the sea to a point called Scotland and thence left on to the Idlewild ILS in a north-easterly direction.

It has been stated that the DC-8 should have held at some point during this approach, but it apparently continued northwards, not making its prescribed right turn to Scotland, and struck the Constellation over the sea just west of Coney Island. The Constellation turned left through at least 90° and crashed on the edge of Miller Army Air Base on the east shore of Staten Island. The DC-8 continued almost straight on to Brooklyn. One of its navigation receivers was unserviceable, but did not necessarily cause the aircraft to go off course.

The cloudbase is reported to have been 600ft at the time of the accident, with snow showers. Both aircraft were supposedly under positive control at the time. It appears to be presumed that the DC-8 was off course and there are many reasons why, with the navigation aids and control techniques in use, it could have strayed. Certainly the task of entering the New York area is complicated and requires successive tuning of a large number of medium- and very high-frequency aids to define the many reference points. Cross-bearings from NDBs and VORs, ranges and marker beacons are all used. Radar advisory service under intensive traffic conditions, without height indications, can be of marginal usefulness. The collision may be only a tragic highlight in a situation which has frequently verged on chaos for years. The traffic density is going to increase, but the navigation system is not going to become more flexible and can only become more complicated or more restrictive.

It is noteworthy that the Waste-King flight recorder, mounted near the forward passenger door of the DC-8, survived the total destruction of the aircraft and was recovered with its record intact. But it was of the present FAA minimum standard and recorded only course, height, speed, vertical acceleration and time by actual scratching of the surface of a broad metal tape several inches wide. Full deflection of the height trace, for example, can only be about one inch and must cover a height range of about 50,000ft. It does not seem likely that a precise flight-profile prior to the accident will be derived from this. The FAA is at present considering increasing the number of parameters to be recorded to up to 80.



The probable tracks of the two aircraft before and after the collision, and their point of impact, are shown in this map of the New York area. The article on this page discusses the circumstances of the accident, and a leading article appears on page 1001

As the map shows there are five civil airports in the New York area, the major "regional" ones being La Guardia, Idlewild and Newark. Already the Port of New York Authority, which owns and operates these five airports, has estimated that the total capacity of the three regional airports of 150 peak movements per hour will be reached before 1965, when an additional major airport will be needed. Busiest of the existing airports is Teterboro, which handles more than 225,000 landings and take-offs annually —mostly by private and business aircraft. Most of this traffic is VFR. In IFR conditions, La Guardia has a peak hourly capacity of 40 movements, Idlewild 70 and Newark 40, giving the total of 150 peak-hourly movements for New York's "regional" airport system as a whole. This capacity has not yet been reached, but it will almost certainly be exceeded long before 1965, when it is estimated that there will be 169 movements at the peak hour. These capacity figures are, of course, determined by the air traffic control system.

Insurance claims resulting from the accident probably amount to well over £5,000,000, including £1,785,000 for the DC-8, £535,000 for the Constellation, liability for each person killed and compensation for loss of property. It is understood that a large proportion of the insurance was placed on the London market.

The accident was the first involving passenger fatalities to a big jet since the first services began in October 1958. There have been four collisions involving civil airliners during 1960, costing 162 lives. In the USA during 1960 there have been seven scheduled-service accidents costing, at a preliminary *Flight* estimate, the lives of 319 passengers and 39 crew. This compares with 271 and 60 killed in 1959.

BACK-SEAT DRIVERS FOR BEA?

REPORTS in the papers about BEA's proposed "commander philosophy," namely the transfer of pilot authority from its traditional place in the left hand seat to the jump seat, will have raised many an airline skipper's eyebrow. These reports emanated from a corporation press release, in the context of the Vanguard, which said:—

"BEA is at present still investigating the possibilities of the new philosophy which introduces the idea of a non-piloting, thoroughly experienced captain sitting in the third seat where he can monitor the actions of his first and second pilots who are directly concerned with the physical handling of the aircraft. As airliners get bigger and more complex in handling and equipment it is thought that the 'commander' crew system would relieve the pilots of certain stresses and provide the further safeguard of expert monitoring."

Some newspapers interpreted this to mean that back-seat driving in BEA is, so to speak, just around the corner. This is not so. The idea began to be discussed in BEA about 18 months ago, but those in favour are believed to be heavily outnumbered; most of the corporation's pilots and senior executives, it is understood, have strong reservations about such a revolutionary change in aircraft command policy.

It is believed also that the BEA members of the British Air Line Pilots Association, and BALPA itself, disapprove of the idea.

Being loaded aboard this British United Airways DC-4 is part of a 19-ton consignment of insecticide recently flown out to the Sudan to save the cotton crop from being destroyed by whitefly. A DC-6A was chartered also. The DC-4 circular windows have, it will be noted, been given the rectangular "DC-6" treatment

SILVER CITY EXTEND OFF-PEAKS

JUST announced by Silver City is the basis on which next summer's cross-Channel fares will be charged. It follows the pattern of every previous year of operation but one by reducing in various ways the cost of taking a car by air from Lydd to Ostend, Calais, Le Touquet or Deauville. The fare adjustments also apply to the ferry between Hurn and Cherbourg, and the seasonal summer service between Manston, Calais and Ostend.

Firstly, in an effort to extend the summer season, off-peak fares in 1961 will be maintained for 40 weeks of the year (between Tuesday, September 19, and Friday, June 30) instead of for 36 weeks as formerly. Silver City claim this to be a longer period than for any other cross-Channel ferry service, air or surface.

Higher charges will still be levied during the three busiest months of the summer, but next year the surcharge on cars applied during July, August and September weekends is to disappear. On an average-length car this amounted to something like an additional £4. There will thus be only two *basic* levels of fare; an off-peak level for nearly four-fifths of the year, and a higher level for the months when loads are heaviest. These basic fares remain unchanged, as do the fares for each length of car and the cost of a passenger ticket.

These changes have been made because the pattern of traffic has altered under the influence of differential fares. Abolition of the weekend surcharge indicates that Silver City believe the alteration to be permanent, and that the trend towards mid-week and off-peak travel will remain even when the inducement is removed. Results of this policy should become clear during the heavy booking season of the next few months.

A startling reduction applies to scooters and motor cycles under 150 c.c., fares for which on all routes have been cut from about £1 to only 2s 6d—the price charged for a bicycle. The vehicle height limit has also been raised—perhaps belatedly—from 6ft 6in to 6ft 10in, since even large vehicles, it has been found, rise only very slightly on their springs once they are installed and shackled down.

TEN SHORT-HAUL LESSONS (continued from page 1004)

a very large extent the result of its complicated system of fare differentials.

There was a strong tendency for many governments to take the view that the best and fairest fare structure was one based on a standard rate per mile for all routes. But charging different people different fares for precisely the same service—i.e., discrimination—might often be good social policy as well as good commercial policy. Fares for inclusive tour passengers were a good example. The American CAB forbade discounts for ITs as unjust discrimination. But the CAB, he thought, was wrong. If the fare reduction was genuinely promotional the result would be that average cost level was reduced, and the normal full fare passenger might be paying a lower fare than otherwise.

Lesson 6: *Cross-subsidization of unprofitable operations by profitable services is a dangerous policy—commercially and socially.*

Internal cross-subsidization could easily lead to faulty allocation of resources. A market economy worked effectively only if prices were related to costs and if firms expanded profitable lines and contracted those which were unprofitable. It was a matter of regret to him that the view of the Select Committee on the Airways Corporations that direct subsidy should be paid to the corporations for social services was not now shared by BEA. It was reasonable that BEA should prefer to be free of subsidy, and the routes concerned [Highlands and Islands] were a sufficiently small part of BEA's total output for there to be no great danger of misallocation of resources. But in cases where cross-subsidization existed on a larger scale the consequent economic problems could be serious.

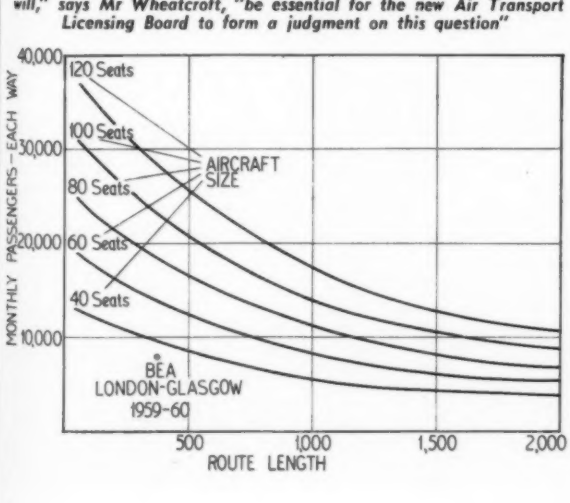
Lesson 7: *Competition is a double-edged sword.*

Mr Wheatcroft accepted the Gill and Bates theory that all the claimed advantages of competition could be achieved by having two airlines on a route: the addition of a third, fourth or fifth airline did not contribute greater public advantage but it did create further economic difficulties by the undue splitting of traffic between carriers.

To establish the traffic level needed on any route before competition was likely to be beneficial (or below which it was almost certain to be harmful) was a difficult but very important question in the economic regulation of the industry. It would be essential for the new Air Transport Licensing Board to form a judgment on this question to guide them in their consideration of the applications which would soon be coming before them.

If there were two or more airlines operating the same route each experienced a fall in its average cost level as its traffic increased. But they only benefited to the extent of their own traffic volume, not to the extent of the total traffic volume. This being so, the Licensing Board would have to compare the probable cost level if one airline was allowed exclusive rights on the route with the alternative of two carriers each probably operating at a somewhat higher cost level but with a greater incentive to efficiency because of the competitive stimulus. The greater the total traffic volume on the route the smaller would be the gap between the two cost levels under consideration and, hence, the stronger would be the presumption that competition would be beneficial.

Fig 3. Traffic volume required to sustain competitive air services. "It will," says Mr Wheatcroft, "be essential for the new Air Transport Licensing Board to form a judgment on this question"



Given frequency, and making an assumption about aircraft size, the traffic volume required for competition could be calculated quite simply. Fig 3 was based on the studies made in Mr Wheatcroft's report *Airline Competition in Canada*. It was possible to use the results plotted in Fig 3 to give an answer, for example, to the question: "How much traffic would be required on the London - Glasgow route to support competitive air services?"

At the present time, when competitive services were almost certain to be operated by Viscounts, the aircraft size was, say, 50-60 seats. At this size Fig 3 suggested that the traffic required for competition was about 12,000 passengers a month in each direction. In a year or two, however, competition was likely to centre around aircraft of at least the Vanguard's performance and no aircraft of less than 80 seats would be available which could be competitive. Hence the minimum traffic required for competition was likely to rise to at least 18,000 passengers per month in each direction. As a matter of interest he had shown in Fig 3 the 1959-60 monthly average traffic carried by BEA on the London - Glasgow route. It did not appear to have enough traffic to justify competitive air services without the risk of incurring a higher level of operating costs.

But he fully accepted the assumption that there were circumstances in which airline competition, within an effective system of economic regulation, might provide a valuable stimulus to more efficient operation and to the provision of better service to the public. It was the responsibility of any licensing board to ensure that competition was encouraged only when it was likely to have these beneficial results.

Lesson 8: *Specialization on particular kinds of operations brings great economic advantages in the airline industry.*

In the West Indies recently he had seen a very good example of the advantages which a small airline might have in dealing with specialized operations. British West Indian Airways had set up a subsidiary airline —Leeward Islands Air Transport—to operate with small aircraft a network of feeder services radiating from Antigua. LIAT had taken full advantage of the economies which could be achieved in a very small, highly personal and entirely specialized organization.

He saw no case for merging BEA and BOAC. On the contrary, there might be good reasons for the establishment of new subsidiaries. For example, BEA ought to find some new organizational form—a semi-autonomous division or a subsidiary company—which would give the Channel Islands routes the specialized management necessary for maximum economy.

Lesson 9: *Various forms of airline co-operation are becoming increasingly desirable and necessary.*

It struck him as somewhat perverse that governments in this and other countries should have chosen the present time to adopt a policy of encouraging more competition when the economic facts of life were causing airlines to move towards closer pooling arrangements to preserve adequate schedules with their much larger aircraft.

Broadly speaking this technical co-operation was taking two forms. On the one hand there were co-operative arrangements between airlines of more or less equal status—the SAS/Swissair consortium, for example. On the other hand, there were arrangements by which small airlines co-operated with large airlines in order to get the technical advantages of the large scale facilities of the big brother—e.g., BEA/Olympic.

There were all kinds of co-operation and he had not attempted to discuss the advantages and disadvantages. But he thought that there was a clear lesson for all airlines that *technical* co-operation was extremely important.

Lesson 10: *Short-haul airline managements must always look after the pennies.*

This meant that airlines must have the best possible system of budgetary control and efficient cost accounting methods to establish standard costs for budgeting. No short-haul airline could be and stay profitable unless it had established an acute sense of cost-consciousness at all levels of its organization. There was no shadow of doubt that this could only be achieved if this attitude of mind was imparted—and put into practice—at the topmost levels of management.

AIR COMMERCE . . .

At the British Air Line Pilots' Association cocktail party in London on December 14. Reading from left to right in all cases: Top row: A. T. Russell, private secretary to Parliamentary Secretary, MoA; D. Follows, general secretary, BALPA; Geoffrey Rippon, Parliamentary Secretary, MoA; and Capt S. L. Arnold-Baakes, vice-chairman BALPA. Basil Smallpeice, managing director, BOAC; Capt J. R. Jeffrey, BOAC; Capt C. G. Klimcke, BEA; and Capt T. H. Farnsworth. *Second row:* Sqn Ldr H. G. Hazelden, Handley Page, and V. C. Varcoe, GAPAN. A. M. Blakemore, BIATA; E. J. Michie, Skyways; P. F. Lewinden, BUA; and Capt P. N. Daymon, BUA. Capt R. P. Wigley, MoA; Capt W. Baillie, BEA; Capt G. P. Watson, BOAC; and W. E. B. Griffiths, MoA. *Third row:* Dr A. R. Sibbald, BOAC; Capt W. B. Houston, BOAC; and Capt F. W. Walton, BOAC. Capt A. Spooner, BOAC; Capt J. Woodman, BOAC; and Capt C. C. Jackson, IFALPA. Capt P. J. Siegel, BUA; Capt R. H. E. Aldridge, BUA; and Maj-Gen C. G. B. Greaves, Cunard Eagle. "Flight" photographs

TWO CERTIFICATES FOR THE ARGOSY

IT is rare, if not unprecedented, for the ARB publicly to compliment a manufacturer when awarding an aircraft a certificate of airworthiness. This happened on December 14, when the chief executive of the ARB, Mr R. E. Hardingham, handed over the Argosy's C. of A. to Mr W. S. D. Lockwood, managing director of Armstrong Whitworth Aircraft at Baginton. Mr Hardingham referred appreciatively to the co-operation that his board has had from AWA, and to the structure of the Argosy and the structural test facilities behind it.

The C of A was awarded two days after delivery of the first Argosy to Riddle Airlines. The occasion was historic inasmuch as, for the first time, ARB and FAA certificates were awarded together. This was a milestone in the long and often divergent roads travelled by the world's two major airworthiness authorities towards the ideal of a unified code. The FAA certificate was presented by the Paris representative of the US agency, Mr L. Morda, to Mr J. Muir, representative at AWA of Riddle Airlines.

Riddle's seven aircraft are all taken from the original production batch of ten laid down when the programme was launched three years ago. For the record, the first aircraft delivered, N6051R, was Argosy No 9, and the second (due to be delivered shortly) was No 10. The others are as follows: Riddle No 3, Argosy No 6; Riddle No 4, Argosy No 5; Riddle No 5, Argosy No 7; Riddle No 6, Argosy No 8; Riddle No 7, Argosy No 2. This leaves three of the original ten aircraft available for early delivery, namely Argosies Nos 1, 3 and 4. These are allocated to BEA, who according to present plans will operate the aircraft in their own right, and not sub-contracted to Skyways.

According to US law, and as specified in the FAA certificate, commercial operations of the Argosy in the USA will, because the aircraft weighs more than 80,000lb, have to be undertaken by a crew of three, including a flight engineer; the aircraft flight deck is arranged accordingly. In their "Logair" work for MATS (which, incidentally, calls for a target utilization of 4,500hr per Argosy per year) Riddle will operate with a flight crew of two.

LICENCES FOR ATCOs

AIR traffic control officers, as first advocated by the profession's Guild in October 1956, are to be required to hold operating licences. Although the requirement does not come fully into force until August 1962, controllers' licences are to be issued from August next year. The award—although not the renewal—of controllers' certificates of competency has already ceased.

Renewable annually, the licences will include up to four ratings: aerodrome control; approach control; traffic director (approach radar) and precision control (radar). All controllers will have to hold the aerodrome control rating, and at airfields equipped with holding, let-down or approach aids, controllers will have also to hold the approach-control rating. Similarly, radar equipment operators will require one or both of the radar ratings. An annual medical examination is now stipulated.

A current aerodrome controllers' certificate of competency entitles the holder to an air traffic controllers' licence with a control rating valid for the aerodrome given on the certificate. This scheme starts on August 15, 1961, and the licence fee is 27s 6d. Examinations for the two radar ratings will take place in London in May and June, and for ATCOs without a current certificate of competency there will be a series of examinations beginning next August. Minimum requirements for a licence in the latter case are the passing of a general examination on aviation law, ATC, meteorology and navigation; a written and oral aerodrome-control rating test and a practical and oral examination associated with each rating. Additional rating examinations will have to be taken where they are applicable.

Excepted from the licence requirements are air traffic officers at MoA aerodromes. Their jurisdiction includes area control and they are already qualified to a standard higher than that to be demanded for an ATCO's licence.

BOAC LOOKS WEST

FIGURES for Britain's air traffic in September 1960, the latest published by the MoA, indicate continued big increases in BOAC's effort on the western routes. Freight in particular increased by nearly 58 per cent in the twelve months ending September 1960 compared with the corresponding period in the previous year (freight on the eastern routes fell by 11 per cent). However, the passenger load factor on BOAC's western routes was about two points down, and overall load factor was more than three points down.

Big increases in domestic traffic were recorded by BEA in the twelve months ended September 1960, total load ton-miles being 30 per cent above those of the corresponding period in 1959. Independent inclusive-tour business showed a healthy increase, being nearly 38 per cent up on September 1959.

DON'T BOTHER TO WEIGH IT

THE FAA has recently approved suggestions by US airlines that for the purposes of load calculations the weight of passengers' baggage should be calculated on an average. This idea, it may be recalled, has recently been adopted for all BOAC aircraft except Boeing 707s. The US average weights are similar to those of BOAC, although not quite the same, BOAC allowing 28lb per passenger for hold baggage while the Air Transport Association (acting for the US airlines) has proposed 26.5lb.

The weights suggested in America would apply to transatlantic and trans-Pacific services. For trans-Pacific services to or from the US. Honolulu or Alaska the hold-baggage weight would be reduced to a calculation value of 23.5lb, plus 5lb cabin baggage.

SUPERSONIC-TRANSPORT IMPLICATIONS (continued from page 1026)

examined by several British firms. For the 200°C of a M2.7 cruise, fused quartz was a possibility, for their shock and thermal stress properties ruled out ordinary inorganic glass materials. There was some hope placed on a sandwich construction, however, with a rubbery interlayer. Existing glass-reinforced resin materials would probably be acceptable for radomes on a M2 aircraft, but their life at elevated temperatures was not yet known. Ceramic materials would almost certainly be required for higher speeds.

Dr Megson told his first questioner, Mr Harper of Bristol Aircraft, that all attempts to modify beryllium had resulted in brittle products. Metallurgically, he saw little hope of beryllium becoming a useful material. The development of sealants for tanks and cabins of M3 aircraft would be very difficult. The best rubber at present available, butyl rubber, loses 50 per cent of its strength at 150°C after two weeks. Silicone rubbers were promising but had poor compression qualities and some unwelcome reactions with certain fluids. A new and promising line of research was into fluorine rubbers.

Another questioner asked the speaker about the parts which magnesium and molybdenum alloys would have to play in supersonics. Magnesium alloys, he replied, must be used in internal parts but not for structures. Oxidization was the bug-bear of molybdenum and he saw no likelihood of its use as a structural material. Of hydraulic fluids, he said that a modified silicone fluid was the most promising to date, being non-inflammable and possessing reasonable lubricity. He was confident that even better fluids would be developed.

In a symposium where both designers and operators had much to say, it was fitting that there should be a representative of the "third force"—Authority. Mr D. M. Jameson, the engineer-in-charge of the Air Registration Board's advanced projects group, was there to remind everybody that they could expect no slackening in airworthiness standards as a concession to the difficulties ahead. The supersonic aeroplane would present the three main types of airworthiness problem in more pressing forms. There must be knowledge of the environment, in a pure form, unmodified by the response of the measuring vehicle and containing, for example, data on wind shear, temperature gradients and hail. There must be knowledge of what the aeroplane will do in that environment and, *before* the start of passenger services, full confidence that the intended safety levels would be achieved.

Mr Jameson said that between 1954 and 1957, aircraft of the USAF Military Air Transport Service had suffered 103 serious encounters with hail. He showed a photograph of the damage which a 3in. hailstone would wreak on a subsonic aeroplane and warned that a supersonic aeroplane would be less capable of taking evasive action. He detailed the many factors that should influence the choice of the proving programme and thought that something like 15,000 flying hours would be needed between first flight and passenger service, to establish the confidence that normal safety levels would be achieved.

Dr Staunton, of Hawker Siddeley Aviation, speaking from the floor, said that although kinetic heating would defeat icing in the cruise, de-icing would demand a considerable heat input during the subsonic phases, particularly as there would be long leading edges ahead of the intakes. He asked whether the ARB considered the present testing methods for pressure failures and transparencies would be sufficient. Mr Jameson replied that pressure-testing methods had been tightened up in recent years. He did not know whether we could afford even more stringent methods. The real improvements must be made in design.

The writer's overall impression at the end of the symposium was that it had been a very worthwhile discussion, with a high "ideas-to-time ratio" maintained right to the end. Nevertheless, there was a nagging suspicion in his mind that some people present wondered whether the effort needed to develop a M2 airliner would be worthwhile in the end. He could not forget a comment overheard during the mudless and bloodless rugger scrimmage which passed for a refreshment break. "It's not at all what we shall want," said a well-known airline man, "it's what the damned competition will involve us in." R. R. R.

BREVITIES

Sir Walter Edmenson has been re-appointed to the board of BEA for a further period of two years from this month.

Ekco CR.178 automatic VHF direction-finding equipment has been installed at Coventry Airport.

TWA is to have six more Super Constellations converted at a cost of $1.7m to all-cargo use by Lockheed Aircraft Services, to increase the airline's all-cargo fleet of these aircraft to 12.

Next month the Tu-114 is to go into service, on the 4,350 st.m. route between Moscow and Khabarovsk. The aircraft will make the flight in 10-12hr.

The FAA has approved Lockheed's engineering modification data for the Electra. Flight testing of the modified aircraft is to continue and the restriction on cruising speed (259 m.p.h. IAS) will remain until the tests are satisfactorily completed and a new certificate is issued.

Demonstrating the comfort of one of two models of the "Mason seat" is Mr E. Gilbert Mason, designer and president of Teco Inc of Burbank, California. A foam-sandwich plastic shell weighing 15lb, it has no shared armrests and the whole seat reclines. It is claimed that 200 can be installed in a DC-8 or 707 at present standards of comfort

The first flight of the Convair 990 is not now expected until January; deliveries, according to *Aviation Daily*, will be delayed for "some weeks."

KLM's annual report for 1959 has been awarded the US *Financial World* award for company reports from among 83 competitors.

An interline agreement has been signed between British United Airways and United Air Lines, the US domestic operator and world's largest airline.

Japanese Government approval has been given to technical co-operation between the Vertol division of Boeing and Kawasaki Aircraft. The latter will produce Vertol 107-2 helicopters under licence.

Montreal's new £11m airport terminal at Dorval was officially opened on December 15. Long-haul passengers depart from an "aeroquay" to which access is gained from the main terminal by two tunnels.

Lufthansa have been authorized to increase their capital of about £15m by about £5.8m. One of the directors has said that he hoped the lion's share would be taken up by the public.

Mr Krobo Edusei, Ghana's transport minister, said earlier this month that by mid-1961 Ghana Airways should have a fleet of 19 aircraft including six Il-18s and two Boeing 720Bs. No announcement has yet been made about the latter contract.

Until the end of October BEA's average fleet of six Comet 4Bs achieved a utilization of six hours per day, carrying 188,000 passengers 146m passenger miles—15 per cent of BEA's summer traffic—at a load factor of 66 per cent.

El Al should start New York services with a chartered Varig Boeing 707-441 in January. The airline's own 707s are expected to become available in May and June. The Varig aircraft will be flown by a Brazilian flight crew and in Brazilian colours.

In return for Eastern's purchase of 40 Boeing 727s the aircraft manufacturer is to accept as a trade-in 40 DC-7Bs which the airline now operates. The deal is subject to CAB approval. The contract is arranged so that for each 727 sold Boeing will take one DC-7B, the whole transfer taking place over 25 months and the piston airliners being sold to Boeing "at a fair market price."

HMS "Albion" on her last commission as a fixed-wing aircraft carrier: during 1961 she is to become the Royal Navy's second Commando carrier ("Flight," last week) and conversion work begins early in the New Year

SERVICE AVIATION

Royal Air Force, Naval and Army Flying News

Lightnings for 56

WHEN the first Lightning was delivered to No 56 Sqn at RAF Wattisham recently it was flown in by an ex-member of the squadron, Peter Hillwood, now a test pilot with the English Electric Co at Warton. No 56, whose CO is Sqn Ldr J. R. Rogers, thus becomes the second Lightning squadron in Fighter Command; the first, No 74, is now fully equipped. It is presumed that Treble One Sqn (like 56, based at Wattisham) will be the third: they are likely to receive their new aircraft in the spring.

Australian Mirages

IT has been confirmed that the RAAF is to have Dassault Mirage IIICs as interceptors to replace its Sabres. A recommendation to this effect, made by the mission which toured the world to look at suitable alternatives, was accepted by the Air Board some months ago (*Flight*, October 21) and went to the Australian Ministers of Defence and Supply for approval: now the Minister of Defence, Mr Athol Townley, has announced selection of the Mirage III and said that delivery is expected to begin in 1963. The initial order would be for 30 aircraft, airframes and engines being manufactured "to a substantial extent" in Australia. He added that the aircraft would have either their existing powerplant [SNECMA Atar 9] or "a new Rolls-Royce engine." A decision would be made by the middle of 1961. The RAAF has already had considerable Rolls-Royce experience with its Avon-powered Sabres.

Coastal Command SASO

A NEW Senior Air Staff Officer has been appointed at Coastal Command: he is Air Cdre K. V. Garside, DFC, who takes over the post next Monday (January 1) with the acting rank of air vice-marshal. He succeeds AVM W. E. Oulton, CB, CBE, DSO, DFC, who is retiring from the RAF at his own request.

Air Cdre Garside, an Oxford rowing blue (1936), has for most of his career been associated with the maritime side of the Service, serving before the war in flying-boat squadrons at home and in the Far East before going to the Middle East in 1940 for three years. From April 1943 he commanded No 262 Sqn (Catalinas) and from early 1944 was CO of RAF Sumburgh in the Shetland Isles. During post-war years he has held Coastal Command staff appointments and been SASO at No 19 Group. His most recent post was that of Director of Quartering at Air Ministry.

Gp Capt John Finch, OBE, DFC, AFC, who has assumed command of RAF Waddington in succession to Gp Capt D. Iveson, DSO, DFC. The new CO set up London - Baghdad and Singapore - Darwin records in 1955 as captain of a Valiant, at 525.48 and 518 m.p.h. respectively

Screening the FAA

CINEMA-GOERS can see the Fleet Air Arm in action in a new film, *Flight Deck*, latest in the Rank Organization's "Look at Life" series. It features deck-landings and take-offs aboard *Hermes* (with *Ark Royal* also making a brief appearance) by Scimitars, Sea Vixens and Gannets, with sequences filmed both at deck level and from a Whirlwind. The colour photography is particularly attractive, and assumes a dramatic quality in scenes of night operations. *Flight Deck* is being shown in company with the new British film *Tunes of Glory*.

The new Canadian Minister of National Defence, Mr Douglas S. Harkness, in the cockpit of a CF-100 simulator at No 1 Fighter Wing (Marville, France) during his recent visit to the RCAF Air Division. With him are Gp Capt D. P. Hall, who commands the Wing, and AVM L. E. Wray, AOC No 1 Air Division

IN BRIEF

The RAF air-firing range on the North Sea island of Sylt is being handed over to the West German Air Force in October 1961. This is part of "a gradual process of returning RAF bases to the West German Air Force."

Three members of the RAAF, Sgt B. W. J. Griffiths, Cpl D. F. W. Blom and LAC J. C. Paull, have been awarded the BEM (Military Division) for their gallantry in a petrol tanker compound fire at RAAF Richmond last March.

A Beverley from No 34 Sqn, based at RAF Seletar, Singapore, flew to Bangkok recently to airlift a medical team and emergency supplies to Vientiane in response to an SOS call from the American-British Thai committee at Bangkok.

The RAF Benevolent Fund has received £4,500 from the SBAC as a result of this year's Farnborough display, in token of the Society's "warm appreciation of the magnificent show by the Royal Air Force, particularly the display by Treble One Squadron."

HMS *Victorious* returned to Portsmouth on December 19 after service in the Mediterranean. Shortly after leaving Gibraltar on December 15 she was visited by the First Sea Lord, Admiral Sir Caspar John, who spent several hours on board watching day and night flying activities.

Prince Chula of Thailand presented flying badges at RNAS Culdrose on December 16 to Fleet Air Arm helicopter pilots on completion of their training. The prince, who has a wide reputation as a Naval historian, lives at Tredthy, near Bodmin, and was flown from his home to the station by Naval Dragonfly.

At the graduation parade of the 88th Entry at RAF Halton on December 21, WO Apprentice John Swinden received not only the Quinton Trophy (awarded to the best ex-ATC cadet passing out on the course) but six other prizes as well. The reviewing officer was Sir Maurice Dean, Permanent Under-Secretary of State for Air.

An anonymous donor has sent a cheque for £25 to the RAF Benevolent Fund as "a small acknowledgement" of his gratitude to two RAF squadrons, Nos 78 and 84, which support Army units in the Western Aden Protectorate. The donor, ex-RA, pays tribute to their members who "so loyally and efficiently kept a few gunners going," referring especially to the Pioneer crews of No 78—who, "regardless of danger to themselves, would evacuate as a top priority any wounded or sick British soldier."

FLIGHT
AIRCRAFT, SPACECRAFT MISSILES

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